2011-06

An analysis of adopting RFID in the Brazilian Air Force uniform sales system

Ratto, Roberto Quintas

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

AN ANALYSIS OF ADOPTING RFID IN THE BRAZILIAN AIR FORCE UNIFORM SALES SYSTEM

by

Roberto Quintas Ratto

June 2011

Thesis Co-Advisors: Geraldo Ferrer
Susan K. Heath

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2011	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE An Analysis of Adopting RFID in the Brazilian Air Force Uniform Sales System			**5. FUNDING NUMBERS**
6. AUTHOR(S) Roberto Quintas Ratto			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Brazilian Ministry of Defense, the Brazilian Government, the Department of Defense, or the U.S. Government. IRB Protocol Number ________N/A____________.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE** A

13. ABSTRACT

The Brazilian Air Force Uniform Sales System (USS) is experiencing continuous sales growth in its points of sale at Air Force bases and an intensive use of labor force in its operations, which have led the Subdirectorate of Supply (SDAB), the USS Central Organization, to designate Radio Frequency Identification (RFID) as a viable option to improve USS operations, currently performed manually.

This project assesses the current state of USS processes, redesigns the processes considering the integration of RFID, and provides a cost and benefit analysis (CBA) of adopting the technology to contribute to SDAB's decision-making process and further studies. The scenario created where RFID is present, and the data (i.e., investments needed, and time and operators utilized) gathered from the SDAB personnel who control and execute the tasks are the basis to assess the potential net benefit associated with the process change.

The CBA focuses on quantitative analysis by contrasting the costs necessary to implement RFID with the savings the technology may produce within the Uniform Sales System. The net present value (NPV) indicates that the RFID implementation intended by SDAB is sufficiently valuable to justify the investments.

14. SUBJECT TERMS Uniform Sales System, Radio Frequency Identification; Cost-benefit Analysis; Net Present Value.			**15. NUMBER OF PAGES** 81
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

AN ANALYSIS OF ADOPTING RFID IN THE BRAZILIAN AIR FORCE UNIFORM SALES SYSTEM

Roberto Quintas Ratto
Lieutenant Colonel, Brazilian Air Force
B.S., Air Force Academy, 1990

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
June 2011

Author: Roberto Quintas Ratto

Approved by: Geraldo Ferrer
Thesis Co-Advisor

Susan K. Heath
Thesis Co-Advisor

William Gates
Dean, Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

The Brazilian Air Force Uniform Sales System (USS) is experiencing continuous sales growth in its points of sale at Air Force bases and an intensive use of labor force in its operations, which have led the Subdirectorate of Supply (SDAB), the USS Central Organization, to designate Radio Frequency Identification (RFID) as a viable option to improve USS operations, currently performed manually.

This project assesses the current state of USS processes, redesigns the processes considering the integration of RFID, and provides a cost and benefit analysis (CBA) of adopting the technology to contribute to SDAB's decision-making process and further studies. The scenario created where RFID is present, and the data (i.e., investments needed, and time and operators utilized) gathered from the SDAB personnel who control and execute the tasks are the basis to assess the potential net benefit associated with the process change.

The CBA focuses on quantitative analysis by contrasting the costs necessary to implement RFID with the savings the technology may produce within the Uniform Sales System. The net present value (NPV) indicates that the RFID implementation intended by SDAB is sufficiently valuable to justify the investments.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I. INTRODUCTION 1
A. BACKGROUND 3
1. Subdirectorate of Supply 3
2. Uniform Sales System 4
3. SIFAREWEB 5

II. RFID SYSTEMS 7
A. RADIO FREQUENCY IDENTIFICATION (RFID) OVERVIEW 7
B. RFID SYSTEM IMPLEMENTATION LITERATURE REVIEW 12

III. METHODOLOGY 15
A. RFID IMPLEMENTATION ANALYSIS 15
1. “As-Is” Assessment 15
a. Collection of Information on Business Processes ... 15
b. Information Analysis 16
2. Process Redesign: “To-Be” Process 16
a. Redesigning Business Processes 16
b. Justification 17
B. COST AND BENEFIT ANALYSIS 17

IV. DESCRIPTION OF THE “AS-IS” USS PROCESS 21
A. ACQUISITIONS FOR THE SDAB’S CENTRAL WAREHOUSE 21
1. Acquisition Procedures 22
2. Receiving of Materials from Suppliers 23
B. DISTRIBUTION TO THE REGIONAL UNIFORMS SALE OFFICES . 24
1. SDAB’s Distribution Routine 26
2. Receiving Material in the PRVF 27
C. INVENTORY 27
1. SDAB’s Center Warehouse 28
2. Regional Uniform Sales Offices 29
D. SALES 29
E. ANALYSIS 29

V. USS PROCESS UNDER RFID TECHNOLOGY (“TO-BE” PROCESS) 33
A. ACQUISITIONS FOR THE SDAB’S CENTRAL WAREHOUSE 33
B. DISTRIBUTION TO THE REGIONAL UNIFORM SALES OFFICES . 35
1. SDAB’s Distribution Routine 36
2. Receiving of Material in the PRVF 38
C. INVENTORY 38
D. SALES 39

VI. COST-BENEFIT ANALYSIS 41
A. COSTS OF ADOPTING RFID TECHNOLOGY 41
1. Tags 41
2. Labor Force 42

3. Hardware 43
4. Software 43
5. Other Costs 43
B. BENEFITS OF ADOPTING RFID TECHNOLOGY 45
1. Process Improvement 46
2. Cost Savings 48
C. ASSUMPTIONS 51
D. RESULTS OF THE ANALYSIS 52

VII. CONCLUSION, LIMITATIONS, RECOMMENDATIONS, AND FURTHER RESEARCH 55
A. CONCLUSION 55
B. LIMITATIONS 56
C. RECOMMENDATIONS 57
1. Small-Scale Proof-of-Concept Testing 57
2. Change Management 58
3. Quality Analysis Performed by the Laboratory 58
4. Continuous Improvement 59
D. SUGGESTIONS FOR FURTHER RESEARCH 59

LIST OF REFERENCES 61

INITIAL DISTRIBUTION LIST 63

LIST OF FIGURES

Figure 1. Uniform Sales System major branches 4
Figure 2. RFID system (From: Digitivity, 2008) 8
Figure 3. Operational requirements and RFID technology choice (After: Apte et al., 2006, p. 34) 12
Figure 4. Framework for RFID system implementation (From: Ngai et al., 2010, p. 2588) 14
Figure 5. Acquisitions for the SDAB'S Central Warehouse flow chart 22
Figure 6. Distribution to the Regional Uniform Sales Offices flow chart............. 25
Figure 7. DMI and PRVF inventory flow chart.. 28
Figure 8. Work flows of the receiving routines in the SDAB 35
Figure 9. Work flows of the distribution to the PRVFs 37
Figure 10. Work flows of inventories at the DMI and PRVFs............................... 39

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

Table 1. RFID technology advantages by feature and benefit classification (After: Lahiri, 2005, p. 49–57) 11
Table 2. USS processes' gaps and problems, quantitative data, and potential applications of RFID technology 31
Table 3. Costs of adopting RFID by the Uniform Sales System (USS) 45
Table 4. Operators, time, and labor-hours allocated to "as-is" and "to-be" USS processes 48
Table 5. Cost savings under RFID technology 50
Table 6. Average wage per hour 51
Table 7. Results of the cost and benefits of adopting RFID 53

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AB2	Standardization Division of the Subdirectorate of Supply
AB3	Uniform Sales Division of the Subdirectorate of Supply
AB6	Procurement Division of the Subdirectorate of Supply
CBA	Cost-benefit Analysis
DMI	Central Warehouse of the Subdirectorate of Supply
ERP	Enterprise Resource Planning
FAB	Brazilian Air Force
IBGE	Brazilian Institute of Geography and Statistics
NPV	Net Present Value
PAM/S	Request for Purchase of Material/Service
PRVF	Regional Uniform Sales Office
RFID	Radio Frequency Identification
SDAB	Subdirectorate of Supply
SIFAREWEB	Intranet-based Management System of the Air Force Uniform Sales System
USS	Uniform Sales System

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

The development of this project was a combination of learning and challenge, whose accomplishment would not be possible without the support of several people.

To my wife Ana, my son Leonardo, and my daughter Luíza, thanks for your love, encouragement and comprehension.

I am very grateful to the Brazilian Air Force, in particular the Aeronautics Economy and Finance Secretariat, my unit, and the Subdirectorate of Supply, for its members' support throughout this study.

To Drs. Geraldo Ferrer and Susan Heath, thank you for your guidance and time, my respect and admiration.

Finally, to the MBA lecturers and students, thanks for your friendship and collaboration.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

The Brazilian Air Force's Subdirectorate of Supply has decided to adopt Radio Frequency Identification (RFID) in its Uniform Sales System supply chain, with the goal of improving efficiency by automating tasks currently performed manually. The continuous sales growth the Subdirectorate of Supply (SDAB) is experiencing in its points of sale at Air Force bases throughout Brazil, along with an intensive use of labor force in its operations, has led that organization to designate RFID as a viable option to enable better performances for existing processes.

The SDAB's plan is to integrate RFID with its intranet-based management system, called SIFAREWEB, and its processes within the Uniform Sales System (USS). After researching RFID, visiting organizations that use the technology, discussing with vendors that provide RFID components and service, the SDAB concluded they should use passive tags to control the uniform items. Based on this choice, a team consisting of SDAB representatives has begun their investigation and data gathering. The SDAB team is currently working on the RFID components specifications that best fit the USS and the costs related to the RFID implementation.

RFID technology has been widely used to control products and provide services, and several successful empirical examples are available in the literature (e.g., Wal-Mart, U.S. Department of Defense). However, the benefits that a new technology such as RFID is supposed to produce may not apply to all business processes as a standardized solution and when in place may not result in an economic gain.

Therefore, the SDAB business process is, as a rule, unique and as such should be studied to assess RFID suitability for the USS operations and the economic consequences of the investment required to transform the actual scenario. Costs and savings involved in the process change should be scrutinized to enable a quantitative evaluation of the implementation proposed.

This project first incorporates the data SDAB has gathered to examine and determine the potential effects of incorporating RFID. It investigates the current USS processes, looks at redesign them considering the integration with RFID, and provides a cost and benefit analysis (CBA) of adopting the technology to contribute to SDAB's decision-making process and further studies. The CBA contrasts the costs necessary to implement RFID with the benefits the technology may produce within the Uniform Sales System. The author builds USS processes flowcharts to illustrate how the operations are today and how they would be after RFID. The comparison between the current routines and the projected new scenario seeks to provide quality outcomes to demonstrate the potential effects of RFID in the USS.

To better understand the current scenario of the USS, the next section presents a background of the SDAB activities, the USS, and the USS' computerized system—SIFAREWEB. Chapter II provides an overview of the RFID technology and discusses the RFID system implementation. In Chapter III, the author describes the methodology used in this project for RFID system implementation process and for cost and benefit analysis. In sequence, Chapter IV describes and analyzes the USS process current state. Chapter V presents the redesigned USS process with RFID present. Chapter VI provides the comparison, results, and analysis of the two scenarios ("as-is" and "to-be"). Finally, Chapter VII provides the conclusions and limitations of the study, recommendations regarding the USS after RFID implementation, and suggested topics for future research.

A. BACKGROUND

1. Subdirectorate of Supply

The SDAB is the USS central organization that plans, directs, coordinates, implements, and monitors USS activities within the Aeronautics Command. The basic tasks and activities of SDAB include the following (Comando da Aeronáutica, 2008):

- Inventory level control within the USS supply chain
- USS purchase planning and procurement execution
- Coordination of item movements within the USS
- Setting sales prices for uniforms
- Financial control within the USS
- USS bookkeeping
- Technical visits to the Air Force points of sales
- USS information technology management

The SDAB is in charge of buying military uniforms from suppliers, storing purchased items, and distributing them to the points of sale at Air Force bases, where members of the Force may buy items as needed. SDAB uses a computerized management system called SIFAREWEB, which integrates the stores located at the various bases. Despite the oversight by the system of the entire chain in terms of sales and quantities stored, SDAB is mainly concerned with the time-consuming inventory handling, which depends essentially on manual labor. Due to intensive use of the labor force, SDAB sees in RFID technology a tool to provide more efficiency to its process and increased control over the uniform items throughout the USS supply chain. They believe the inherent automation of RFID can reduce the time spent in USS operations and provide more consistency between physical inventories and the SIFAREWEB records.

2. Uniform Sales System

The responsibility of USS is to supply uniforms and related parts to the points of sale, located at Air Force bases, for purchase by the military personnel. The system has four major branches, which are illustrated in Figure 1:

- SDAB's Uniforms Sales Division (AB3) – in charge of performing the acquisition plan, setting stock levels, coordinating the item movements within the supply chain, setting uniforms sales prices, controlling the financial resources from the sales, and supervising management actions within the USS
- SDAB's Central Warehouse (DMI) – responsible for receiving and storing the material supplied by contractors, distributing the uniforms to the points of sale, and controlling the inventory levels
- SDAB's Standardization Division (AB2) – responsible for the quality analysis and approval of the material received from suppliers
- 28 Regional Uniforms Sale Offices (PRVF) – in charge of the sales to the AF military personnel

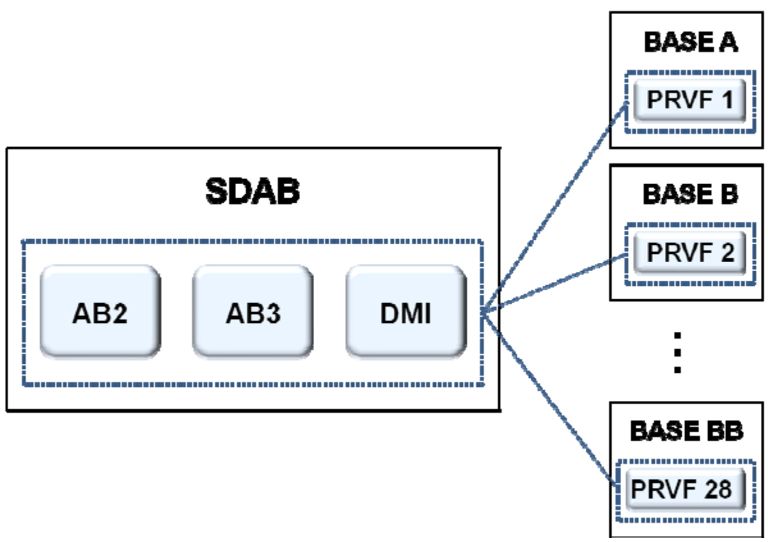

Figure 1. Uniform Sales System major branches

3. SIFAREWEB

The SIFAREWEB is an intranet-based management system used in the AF USS. The system links the SDAB's Uniform Sales Division, the SDAB's Central Warehouse, and the 28 USS points of sale spread throughout Brazil. The SIFAREWEB enables the visibility of the warehouse and each point of sale stock item, and tracks the sales. The SDAB centralizes the management and shares the system maintenance with a contractor. Currently, the SIFAREWEB manages about 1,000 different types of items, and approximately 200,000 items were sold in 2010.[1]

[1] Data gathered from SDAB's intranet-based system (SIFAREWEB) in December 2010.

THIS PAGE INTENTIONALLY LEFT BLANK

II. RFID SYSTEMS

RFID is widely used by different types of organizations and the proliferation of the technology in our daily lives is incontestable. Since the technology has large room for improvement (Lahiri, 2005), it is important to revisit its characteristics, and know how to implement the system to obtain the best value added to a business process. In an effort to address those two issues, this chapter provides an overview of the RFID system and discusses RFID implementation.

A. RADIO FREQUENCY IDENTIFICATION (RFID) OVERVIEW

RFID is an automated identification technology that uses radio waves. The technology was first used during World War II by the British military, and its first commercial use occurred in the 1980s (Read et al., 2004). In recent years, RFID has been widely explored and successfully applied in many different areas, such as medical care, asset tracking, warehouse management, and retail business (Ngai et al., 2008). Today, there are many potential large-scale applications of RFID in both enterprise and customer routines due to current cost decreases, as well as the very practical physical size and form of RFID tags.[2]

In response to growing interest in RFID, several publications and websites provide extensive information on the subject (e.g., RFID Journal[3]). In addition, there are several standards bodies and organizations (e.g., EPCglobal, American National Standards Institute, and International Organization for Standardization) to deal with different aspects of RFID technology aiming to enable design and implementation of robust, open, and compatible working systems (Lahiri, 2005, p. 209).

[2] RFID tag is a device attached to the material or person to be identified by a RFID system.

[3] RFID Journal website: http://www.rfidjournal.com/.

The most basic RFID system is made of three major components: a tag or tags made of different materials for specific applications; a reader, which is also known as an interrogator, to communicate with the tags; and the system supporting infrastructure, composed of both hardware and software. RFID is a system that put “tags” on objects, so they can be identified, tracked, and managed automatically utilizing radio frequency equipment and supporting computer systems. The purpose of an RFID system is to enable data to be transmitted by a tag, which is read by an RFID reader and processed according to the needs of a particular application. The data—the most valuable component of the RFID system (Brown, 2007)—are transmitted by the tag and may provide identification or location information, or specifics about the product tagged. Figure 2 illustrates a basic RFID system.

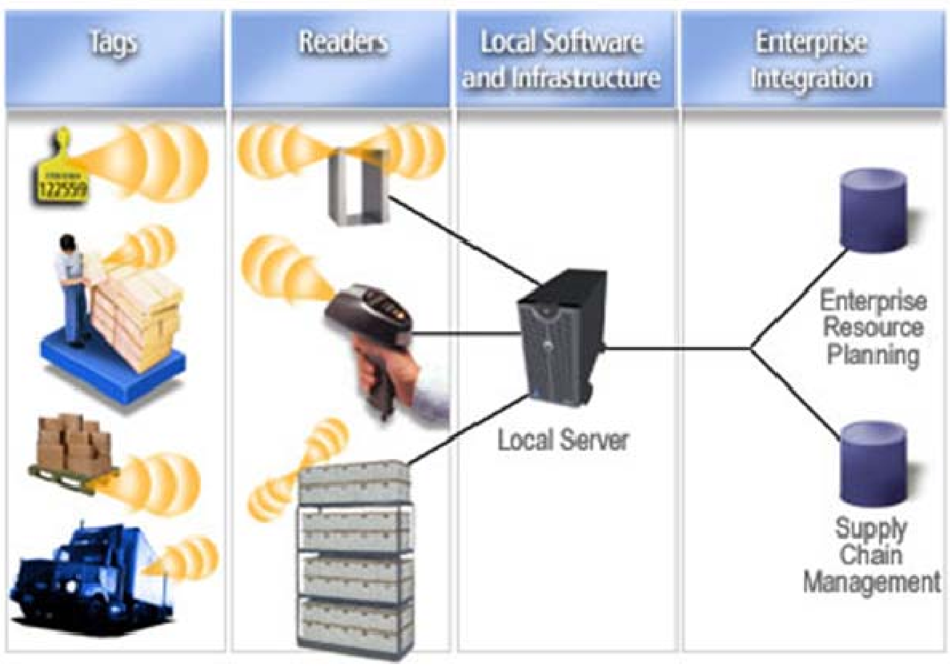

Figure 2. RFID system (From: Digitivity, 2008)

The basic RFID system has the following components:[4]

- Tag – A device attached to the material or person to be identified and tracked. It is also called a “transponder.” The RFID tags are classified as active, passive, or semi passive, based on the means by which they transmit messages.
- Reader – An apparatus that stimulates tags, reads their data, and transmits it via a network to a host computer. In the simplest case, the reader transmits a query, and any tags within its field transmit their contents.
- Antenna – A device that converts energy between flowing electricity and broadcast radio waves. Both readers and tags have antennas.
- Software – There are two categories of software: RFID middleware and application software. The middleware task is to convert the raw database that readers create into useful and meaningful information. The application software is the Enterprise Resource Planning (ERP) application of a company.
- Communication Infrastructure – A component composed of both wired and wireless circuitries needed to connect all the above components. This enables the system components to communicate with each other.

Different from bar codes,[5] RFID is more automatic, and is capable of higher speed operations (Brown, 2007). In addition, it collects data that bar codes may not be able to handle. Coyle (2005, p. 486) states, “RFID is an advanced technology compared to barcodes." This does not mean RFID will replace bar codes (Lahiri, 2005). Brown (2007) emphasizes that there are “differences”

[4] The components’ descriptions are drawn from Lahiri (2005) and Brown (2007).

5 The mention of bar codes is due to the controversial view that RFID is the next evolution of the bar codes. Brown (2007) says more about the difference between the two tools.

between RFID and bar code technologies. Each has its own advantages and disadvantages. Thus, the more likely scenario is the co-existence of the two technologies.

Lahiri (2005) describes eight advantages of RFID technology. Table 1 summarizes those advantages and classifies the benefits according to whether they are immediate or there is a potential for future improvements. If there are only immediate benefits, the implication is that there are not additional benefits to be realized in the future. As seen here, “contact-less” and “multi-read ranges” are the only two features the author considers limited in terms of improvement. The RFID technology has much room for improving the other features.

Table 1. RFID technology advantages by feature and benefit classification[6] (After: Lahiri, 2005, p. 49–57)

Feature	Description	Benefit
Contact-less	No contact between the readers and tags	Immediate
Writable data	Tags may be recycled from 10,000 to 100,000 times if needed	Immediate and future
Line of sight independent	Read and write data through obstructing objects	Immediate and future
Multi-read ranges	Choice of tags is an available option depending on the radio frequency required (i.e., LF, HF, UHF, or MW)	Immediate
Variety data-capacity range	A tag can carry a variety of bit or memory capacity to fit the application requirement (i.e., 1 to 96 bits and even more in some special applications)	Future
Multiple tag read options	Reader can auto-identify multiple tags both in motion or Stationary	Immediate and future
Durable	Tags can operate in and survive harsh environmental conditions	Immediate and future
Smart task enhancer	Performance of tasking (e.g., recording temperature exposure in the food industry, or anti-theft application [e.g., high-value item])	Future

Having identified the need for use of RFID technology, one can select the type of system that best fits a particular type of business. Further researches may cite Brown (2007), Jones and Chung (2007), and Lahiri (2005); authors who provide detailed studies about RFID technology; criteria to select RFID components; and business case examples that help practitioners to figure out what best fits to their processes. Apte et al. (2006) present a multi-case study in which they identify the benefits RFID technology provides in terms of four major

[6] Table constructed based on the RFID advantages discussed by Lahiri (2005).

capabilities of an operation: quality, speed, flexibility, and cost. Based on the analysis of how RFID technology was chosen in the cases presented by the authors, they also propose a conceptual framework in the form of a set of rules that help managers select the most suitable technology configuration for their operational needs. Figure 3 illustrates the “minimum information” commonly used that lead to the “choice of RFID technology” configuration. The framework calls managers’ attention to revisit their operations to select the suitable RFID configuration taking into account the limits imposed by technical feasibility in their business processes.

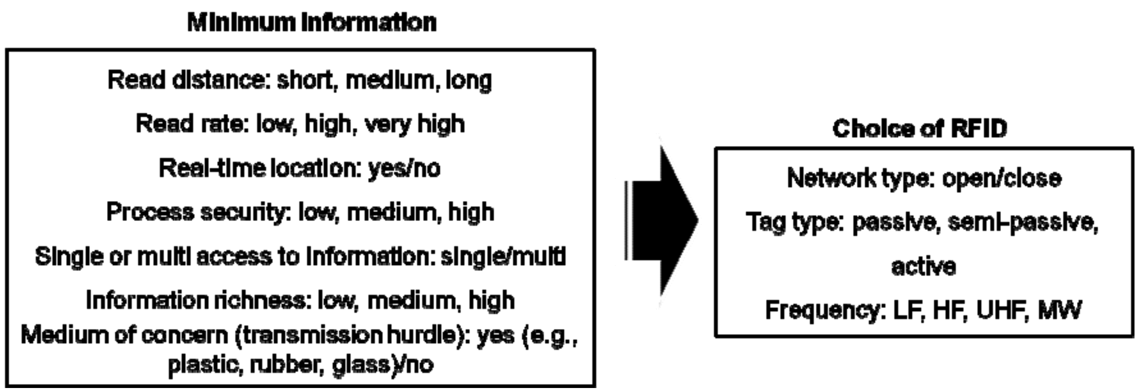

Figure 3. Operational requirements and RFID technology choice (After: Apte et al., 2006, p. 34)

B. RFID SYSTEM IMPLEMENTATION LITERATURE REVIEW

RFID system implementation is a complex process. Organizations can easily purchase the technological components necessary for a new technological system; however, the implementation phase commonly includes significant difficulties arising from the learning burden (Fries et al., 2010). That is, the implementation goes beyond the technical aspects of system development and deployment, involving human issues, organizational issues, the physical environment, and business processes; it also requires skill, knowledge, and people, from frontline staff to senior management, to support and commit resources to accomplish the implementation (Ngai et al., 2010). Fries et al. (2010) say that the effective use of RFID technology depends on the implementation behaviors of the channel partners; not only should the one who has the initiative to adopt RFID technology make investments and changes in their processes, but also the other network trading partners. They advocate, “The implementation of RFID programs across channel relationships is a complex and highly interdependent process” (Fries et al., 2010, p. 590). Jones and Chung (2007) add that the implementation of a RFID system can provoke significant changes in the way the organizations function.

Ngai et al. (2010) acknowledge there are successful RFID implementations well reported in short cases in trade magazines, RFID vendor websites, and white papers from vendors; however, the reports are mainly journalistic and promotional in nature. In turn, case studies of the implementation of RFID mostly focus on given organizations and their particular experiences- they cite four references.[7] Only a handful of research studies have attempted to set out the lessons learned from implementation in detail, which are valuable and have important implications for implementing RFID systems elsewhere (Ngai et al., 2010).

Aware of theoretical discussions and several case studies on the RFID system implementation, such as the United States Department of Defense and Wal-Mart (Lahiri, 2005; Brown, 2007; Jones and Chung, 2007), Ngai et al. (2010,p. 2583) observe that “there is no comprehensive framework to understand the implementation process, its relevant activities and issues.” Therefore, they developed a useful RFID implementation guide that consists of seven major stages, and covers technical and non-technical issues. Figure 4 illustrates this framework. As seen here, the multi-stage process flow is not only a comprehensive picture that managers can use to better understand the RFID

[7] Case studies: Volvo, by Holmqvist and Stefansson, 2006; A Chinese bathtub company, by Liu and Miao, 2006; Wan-Fang hospital in Taiwan, by Kuo et al., 2007; and The parking system of city of Novi Sad, Republic of Serbia, by Ostojic et al., 2007.

implementation process, but one with which they can explore any issues related to any RFID implementation steps (e.g., RFID project development, processes changes, and investment decisions).

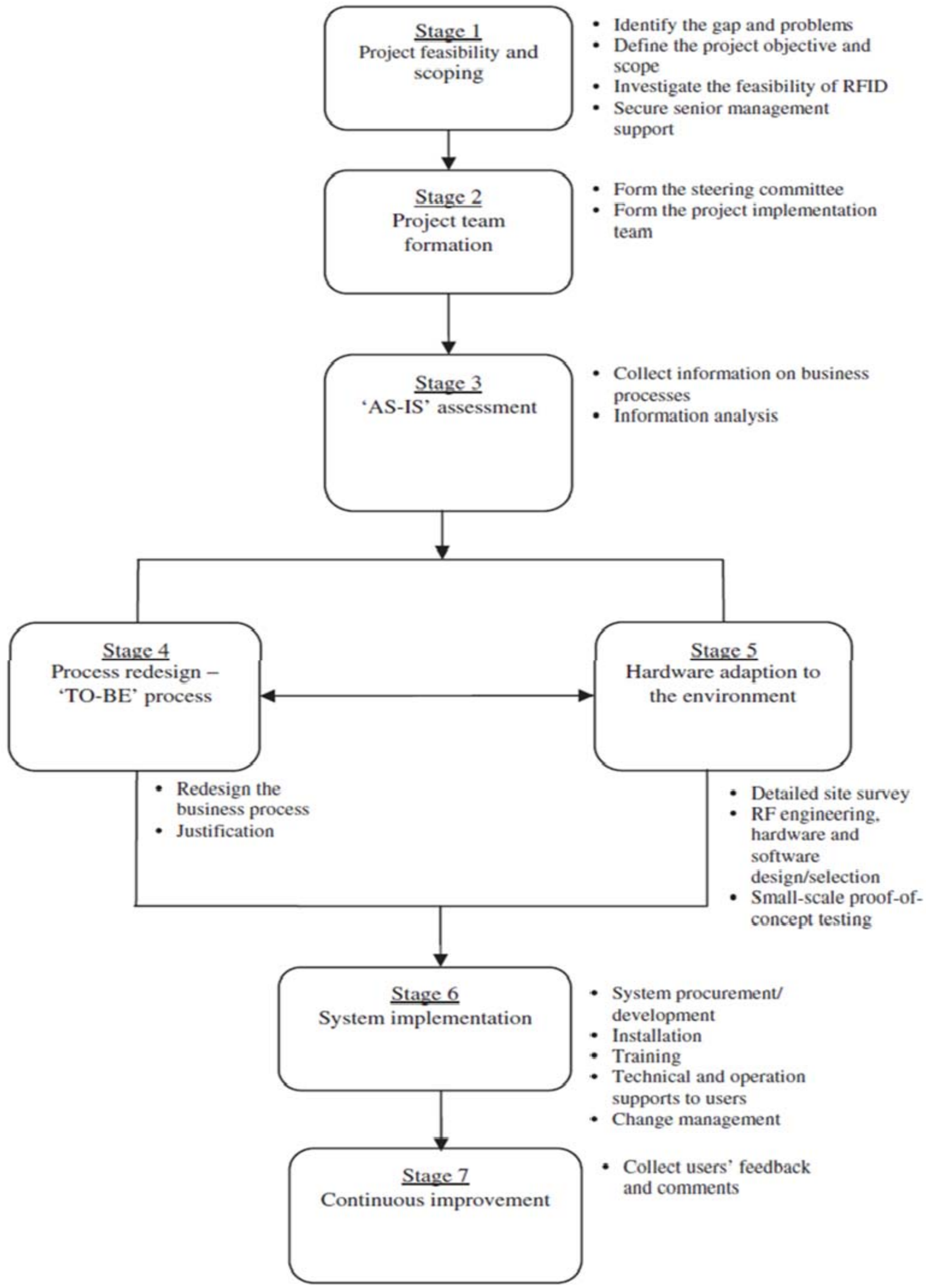

Figure 4. Framework for RFID system implementation (From: Ngai et al., 2010, p. 2588)

III. METHODOLOGY

This chapter presents the set of methods used to assess the current USS process and the redesigned process as a way to scrutinize the operations that RFID may affect. It also describes the CBA model applied to the SDAB's RFID implementation project, which is in the final specification stage.

A. RFID IMPLEMENTATION ANALYSIS

Given the current stage of the SDAB's project, in which a team is already working on the desired RFID system specification, this study focuses on Stages 3 and 4 of the framework proposed by Ngai et al. and presented in the previous chapter (Figure 4): "as-is" assessment and process redesign – "to-be" process. The following section describes the methodology, and Chapters IV and V present the "as-is" and "to-be" information for the USS RFID project.

1. "As-Is" Assessment

The "as-is" assessment is the evaluation and analysis of the current business process state. It involves the collection of information on business process and information analysis as follows:[8]

a. Collection of Information on Business Processes

- Information and data on the equipment, operations, activities, documents, forms, and templates of the relevant business processes that fall within the scope of the RFID implementation
- The flow of data and information in the business process for further analysis
- The physical flow of the individual items, pallets, cases, and assets that may be tagged

8 The detailed steps of the collection of information on business process and information analysis are drawn from Ngai et al. (2010).

- The daily decisions made during business processes
- Visits to all sites or a sample of the sites where related processes are performed

b. Information Analysis

- Analysis and evaluation of the current state of the business processes based on the information gathered
- Identification and analysis of the gaps and problems
- Definition of what can be resolved by implementing the RFID system and thus the requirements of the RFID system

2. Process Redesign: "To-Be" Process

The process redesign—the "to-be" process—involves the definition of future scenarios after the implementation of RFID technology, and the qualitative and quantitative justification of the new business processes[9], as follows:

a. Redesigning Business Processes

- Understanding of how the new business processes related to RFID will work before making any changes to ensure that the company can safely change its operations environment
- Business processes have to be fully documented
- Selecting the right set of business processes to which RFID technology can be applied
- Some procedures in the existing business process may be simplified or changed, and new procedures may be added to improve the quality of the existing processes

[9] The detailed steps of redesigning business processes and justifying them are drawn from Ngai et al. (2010).

b. Justification

- Estimate the costs and savings anticipated from RFID implementation in a given new business process. The cost of implementing RFID technology should include the fixed infrastructure costs (e.g., the cost of the readers, network upgrades, and installation), the variable costs (e.g., cost of the tags), and the maintenance cost per year.
- The company may benefit from savings in lead-time, human effort in data recording and searching for lost items, and the cost for extra material inventory to compensate for lost items. These savings should be included in the calculations.
- Small-scale proof-of-concept testing helps to justify the "to-be" scenarios quantitatively. Such tests will ensure that the redesigned processes under RFID technology are ready for deployment, and that all limitations have been resolved. They will enable the feasibility evaluation of the new processes technically and operationally.

B. COST AND BENEFIT ANALYSIS

The SDAB's objective of adopting RFID technology is to improve efficiency, which means, among other definitions, doing the best by making an optimal use of the resources available. To improve efficiency, an investment in a process change, such as the project proposed by SDAB, should provide a better outcome in the new scenario than the current one, and the benefits must outweigh the costs.

A cost-benefit analysis (CBA) is a model widely applied to asses a public project, and an approach to making economic decisions of any kind. It is used to evaluate the total anticipated costs of a project compared to the total expected benefits in order to determine whether the proposed adoption is worthwhile, or will improve efficiency (Merkhofer, 1987). If the results of that comparison suggest that the overall benefits associated with a proposed change outweigh the costs, then the organization will most likely choose to follow through with the implementation. CBA requires identifying the project, recording tangible or intangible costs and benefits, monetizing them, adjusting for the time value of money, and then calculating net benefits by subtracting total costs from total benefits.

Prest and Turvey (1965) say that “cost-benefit analysis is a practical way of assessing the desirability of projects, and it implies the enumeration and evaluation of all the relevant costs and benefits” (p. 683). Brent (2009) reinforces that “the end result of a CBA must be a judgment or decision about the desirability of a project” (Brent, 2009, p. 4). Based on the authors’ statements, a well-conducted CBA is crucial for the decision making process; a flimsy CBA is more likely to result in bad decisions.

The CBA concept is simple and the proposed comparison between costs and benefits is intuitive (Bentkover et al., 1986, p. 5). However, it is not a simple matter to enumerate and evaluate all relevant costs and benefits in an investment project (Prest and Turvey, 1965). CBA is not just an evaluation technique, where you plug the available numbers in a formula, and present the results. According to Brent (2009), it is “a way of thinking whether you have collected the right type of data” (p. 4). In this sense, a solid cost and benefit analysis of adopting the RFID in the USS should rely on a scrutiny of the current USS process, a deep knowledge of the SDAB’s project, and the appropriate design of the new scenario where RFID is present.

In general, authors who study RFID dedicate a specific portion of their work to the justification of the technology adoption (Lahiri, 2005; Sweeney, 2005; Jones and Chung, 2007; Brown, 2007). They suggest identifying the investment costs and the benefits of a project proposal by building business cases with the help of diagrams. The organization’s processes should be examined in detail to design the two operational scenarios (with and without the RFID technology), and demonstrate the changes quantitatively and qualitatively. As common sense, the authors use the basic premise of cost-benefit theory, which leads to a systematic comparison of the advantages (benefits) and disadvantages (costs) that result from the estimated consequences of a choice (Merkhofer, 1987, p. 60).

A business case developed for a CBA starts with a creation of business-flow diagrams to identify or revisit the major processing steps (Lahiri, 2005; Sweeney, 2005; Jones and Chung, 2007; Brown, 2007). Lahiri (2005) says that several characteristics of the operations might become evident just from analyzing the diagram. The analysis is important because it gives the opportunity for managers to eliminate redundant activities in the business processes or make changes in inefficient organizations' operations in the supply chain before considering the RFID presence. In addition, an RFID implementation project designed to improve operations free of unnecessary or not well-designed steps does not tend to overestimate the potential benefits provided by the technology, which makes that project consistent and its justification more credible.

After describing the current business process, managers should look at the supply chain to find points in which the RFID technology will make positive differences. The benefits may include timesaving in handling inventory, labor cost savings, improved inventory accuracy, lower holding costs, and low incidence of stock out (Lahiri, 2005; Sweeney, 2005; Brown, 2007; Sarac et al., 2010). The key here is to gather data and monetize the benefits in terms of cost savings and actual gains. Sweeney (2005) says that quantifiable benefits are the key benefits one can test and support with calculations. Brent (2009) advocates that "what is important is the monetary amount of any benefits not the size of benefits list" (p. 5).

By knowing where RFID may improve a business process, the task of figuring out the investment needed to implement the RFID system is not too hard. Nowadays, the growing application of RFID solutions, the standards organizations, and the number of vendors in the market provide conditions for a company to gather information about costs easily. Lahiri (2005), Sweeney

(2005), and Brown (2007) list the following costs associated with almost every variable of an RFID system, classified into one-time costs and ongoing costs:

- One-time costs: RFID hardware, software, training and education, downtime in operations to accommodate installation, and application integration
- On-going costs: services, maintenance, and disposable tags

A cost-benefit analysis that thoroughly identifies and realistically quantifies all costs and benefits in a justification process is an accurate way to determine whether a proposed project is worthwhile. It reduces complex expectations, benefits, and costs to a single defensible number that enables managers to visualize the result of their business process change, and make decisions.

IV. DESCRIPTION OF THE "AS-IS" USS PROCESS

Using the framework Ngai et al. (2010) propose (Figure 4), the author gathered information about the current USS process and operational environment by studying SDAB's instructions and rules. Data was also collected through telephone calls and messages exchanged with one officer of the SDAB in charge of coordinating the effort of gathering information, and from SIFAREWEB, to assess and evaluate USS' current state. The data collection has focused on the USS-related routines, particularly those in which RFID technology may influence or affect.

The USS can be analyzed as four main processes: (1) the uniform acquisition for the SDAB's Central Warehouse (DMI), (2) the distribution of the products to the Regional Uniform Sale Offices (PRVFs), (3) inventories in the DMI and PRVFs, and (4) the PRVFs' sales. The description of those processes is associated with the data collected, and illustrated by flow charts for better understanding of the supply chain. The last section in this chapter presents an analysis of the current routines, points out their problems or gaps, and indicates which processes the RFID technology would affect.

A. ACQUISITIONS FOR THE SDAB'S CENTRAL WAREHOUSE

The SDAB centralizes the uniform acquisition, receiving, and storage for the USS. It plans the acquisition and executes the budget to replenish the DMI stock on an annual basis. Based on the sales and stock levels data provided by the SIFAREWEB, the SDAB runs the procurement process and receives the uniforms from suppliers in one year to ship them to the PRVFs in the next year. The following description of the acquisition procedures and the receiving activities includes both the time spent and the human resources involved in the activities performed in 2010 for further analysis in this project. Figure 5 presents the flow of acquisition activities for the SDAB's central warehouse process, described in detail here.

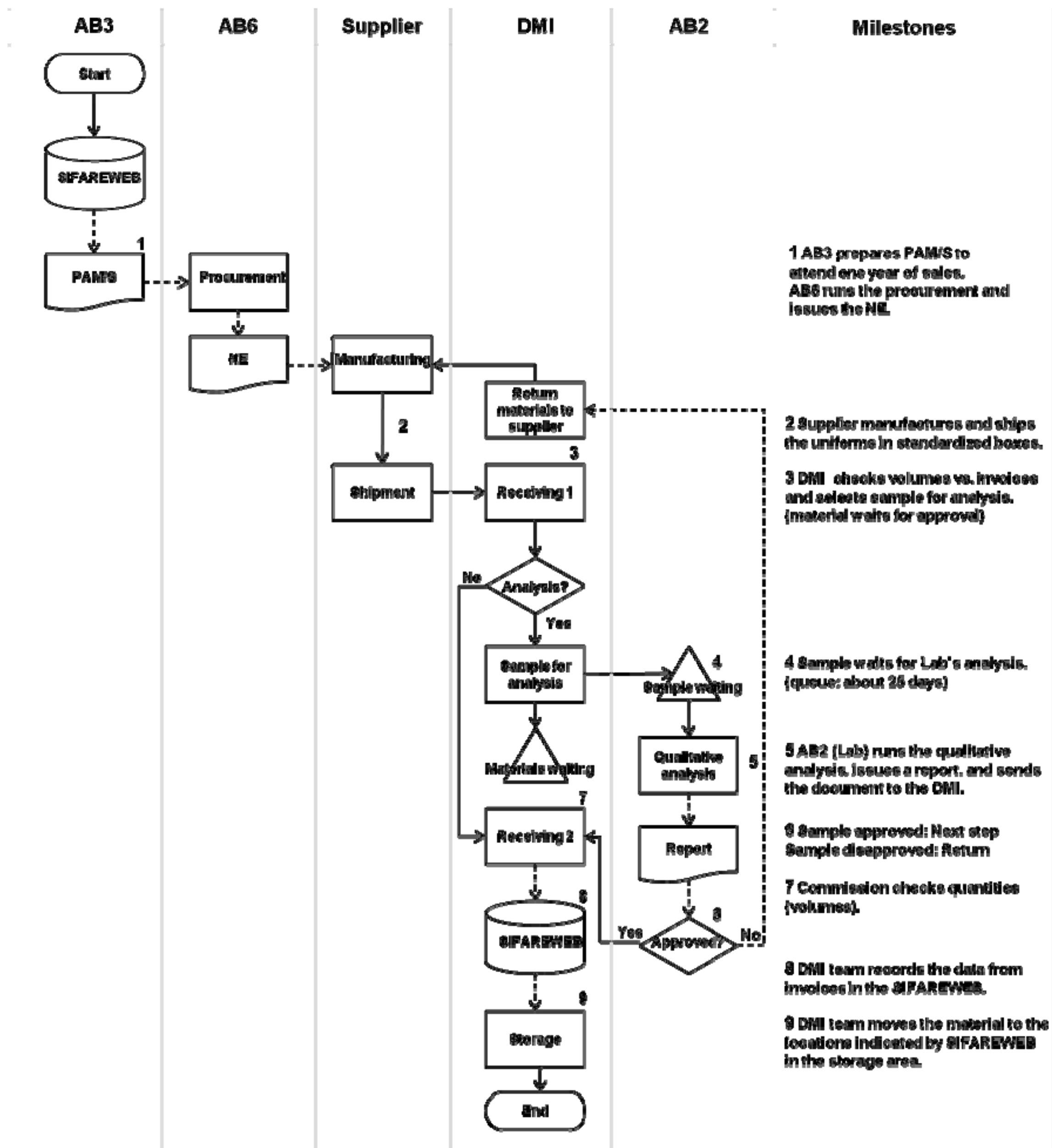

Figure 5. Acquisitions for the SDAB'S Central Warehouse flow chart

1. Acquisition Procedures

The Uniform Sales Division (AB3) starts the acquisition process by issuing the Request for Purchase of Material/Service (PAM/S) based on the existing data in the SIFAREWEB. AB3 forwards the PAM/S to the SDAB's Procurement Division (AB6), which runs the procurement. The SDAB, as a government institution, follows Law nr. 8666 regarding government procurement (Brazilian National Congress, 1993), and uses an electronic bidding system ("pregão eletrônico") regulated by Decree nr. 5450 (Presidency of the Republic of Brazil, 2005) for its acquisitions. The supplier that wins the bid receives the Statement of Commitment ("Nota de Empenho–NE"), which works as a contract and obligates the SDAB's budget.

As a rule, AB3 requests the items necessary to meet the estimated sales for a period of one year. This would appear to be because the budget is annual, but is actually mainly due to the lengthy procurement process, which may take about seven months for completion. Depending on the prices obtained in the bidding, the AB3 may increase the quantities of items requested to expand the inventory of the SDAB’s Central Warehouse to prevent stock-out due to any potential budget constraints in the future. Upon receiving the NE, the supplier produces and delivers the material to SDAB. The time to complete this step is three to six months. Therefore, the time between the AB3’s request and the actual product delivery may last one year. The average number of items purchased annually is 511,430, and the average annual cost is US$ 2,285,100.[10]

2. Receiving of Materials from Suppliers

The suppliers pack the materials purchased by SDAB in standardized cardboard boxes, and usually deliver them by contract carriers. The DMI checks the quantity of boxes and the invoices (i.e., initial receiving), to release the carrier. In 2010, the DMI received 5,800 boxes requiring approximately 29 working hours of four people (i.e., one sergeant and three soldiers), which corresponds to a capacity of 200 boxes received per labor-hour. After placing the boxes inside the warehouse, the DMI sends one sample of size 1 of each type of item received to the laboratory of the Standardization Division (AB2) for qualitative analysis. The laboratory analyzes the samples and writes a report.

[10] This project uses the exchange rate of US$1.00 = R$1.67, effective on December 31, 2010. Retrieved from http://www.bcb.gov.br/.

The time to analyze the material for each sample ranges from 2 to 4 hours on average. However, the DMI waits up to 25 days on average to receive the report and cannot move any item received before laboratory's approval. The long waiting period occurs because the current capacity of the laboratory cannot meet the demand appropriately. Among all analyses the laboratory performed in 2010, 405 of them were conducted to meet USS demand.

If the laboratory disapproves the uniform sample, DMI sends the products back to the suppliers for replacement or repair, as appropriate. If the delivery is approved, a commission consisting of one officer (major) and two sergeants counts the boxes to be stored in the warehouse (i.e., final receiving). In 2010, the commission spent 150 hours to check 300,000 items (171 invoices) with an average of 2,000 items (items in boxes) per hour. Based on the documentation issued by the commission, the DMI's team records the invoices data in the SIFAREWEB, and places the products on the warehouse shelves indicated by the SIFAREWEB for future distribution. The recording data took 70 working hours of two people from DMI; the storage consumed 750 hours of one sergeant and four soldiers, which corresponds to 400 items stored per hour by the team.

Figure 5 illustrates the entire acquisition process from the AB3's material request up to the storage in the DMI, and presents the process milestones to aid in describing the process flow. The process flow seems to be appropriate, but the SDAB says the time spent in handling material is an issue. Moreover, if DMI did not hold large inventories, the limited capacity of the laboratory would cause delays and increase the probability of stock-outs.

B. DISTRIBUTION TO THE REGIONAL UNIFORMS SALE OFFICES

Currently, the DMI performs the pick and pack activities at its full capacity. The AB3 uses the DMI's limitation as a constraint to prepare the PRVFs' replenishment plan. The idea is to provide sufficient items to the PRVFs to meet the sales demand until DMI is able to deliver again. Considering the continuous sales growth, the limited PRVFs' storage rooms, and the personnel and time constraints, the distribution process is the biggest of SDAB's concerns because it limits the USS expansion, and it implies future stock-outs or more costly deliveries. The procedures and the PRVFs' sales data presented below refer to the 2010 distribution process and performance. Figure 6 presents the USS' current distribution process flow, detailed here.

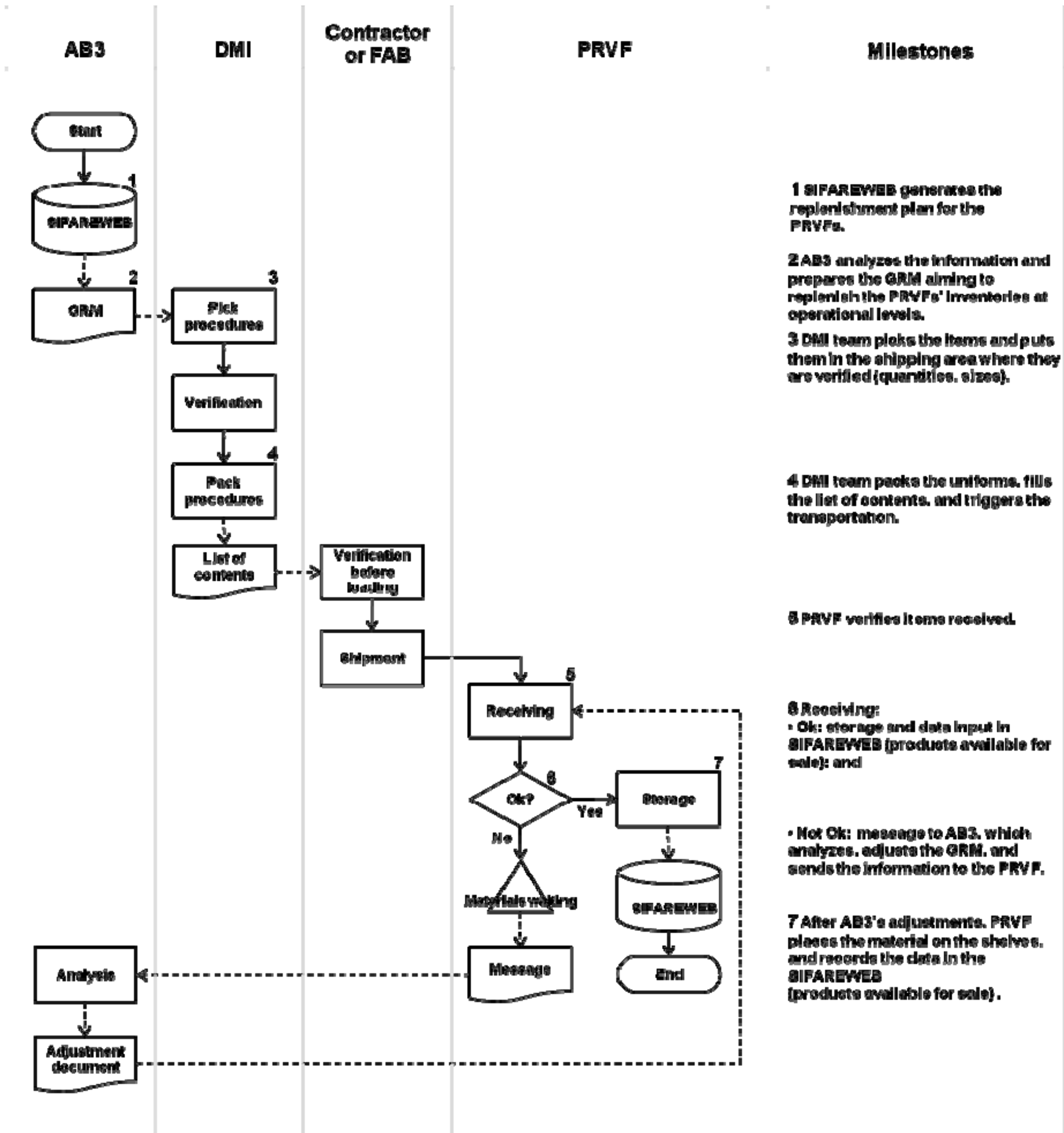

Figure 6. Distribution to the Regional Uniform Sales Offices flow chart

As seen here in Figure 6, there are no redundant activities in this process; the process structure is lean. However, the intensive use of the limited labor force makes the uniform distribution a cumbersome process that needs improvement in terms of speed.

1. SDAB's Distribution Routine

Based on the information generated in the SIFAREWEB, AB3 plans the uniform distribution to the Regional Uniform Sales Offices (PRVFs), and prepares the waybills (GRMs) for the DMI to prepare items for distribution. The supply seeks to restore the operational level of each PRVF's inventory (i.e., 4 months of sales). The AB3 uses the average of the best quarter sales (adding backorders) as a forecast method to define what to distribute to each point of sale. In 2010, AB3 prepared 420 GRMs, and the DMI shipped the items to the PRVFs in five ways:

- SDAB's trucks: 38 deliveries
- Contract ground transportation: 62 deliveries
- AF trucks: 131 deliveries
- FAB aircraft(taking advantage of other predefined missions): 42 deliveries
- Mail (in exceptional cases, where the on-hand inventory cannot fulfill the demand for a certain item): 147 deliveries

A sergeant and three soldiers work in the warehouse to handle the items described in each GRM. In 2010, the DMI distributed 222,600 items under 420 GRMs, and spent 1,724 hours to pick the material; this equates to 129 items picked per hour on average. The team places the items in the shipping area where two other airmen verify the quantities with the GRM, pack the products into boxes for delivery, and create a list of contents. In 2010, those two people spent 448 hours working together to accomplish their tasks, being 90% devoted to verifying the quantities and 10% to packing the uniforms, which represented

498 items processed per hour on average. Before loading for shipment, the person or company in charge of delivering the uniforms verifies the number of boxes against the list of contents. In 2010, two people of the DMI team devoted 14 hours to perform that task.

2. Receiving Material in the PRVF

The PRVF team opens the boxes from SDAB upon receipt, and checks the uniform items individually. In 2010, all PRVFs together spent 6,300 hours receiving material delivered by the DMI. One sergeant and one soldier per PRVF worked 225 hours on average verifying 35 items per hour. As a rule, when there are inconsistencies between the delivery and the GRM, the PRVF and AB3 exchange messages to solve the problem. The AB3 analyzes the discrepancies pointed out by the PRVF and adjusts the GRM; DMI sends the missed items to the PRVF right away and items in excess eventually return to DMI. In 2010, adjustments for more or less amounted to 7,060 items, which represented 3.17% of the total items handled (i.e., 222,600 items).

C. INVENTORY

Inventory is a straightforward activity. Both DMI and PRVFs adopt a routine consisting of printing a list of the items in stock from SIFAREWEB, and then checking physical quantities. Again, the main concern is the time spent and personnel involved in performing the inventories manually. Figure 7 illustrates the common inventory process flow performed by the DMI and the PRVFs.

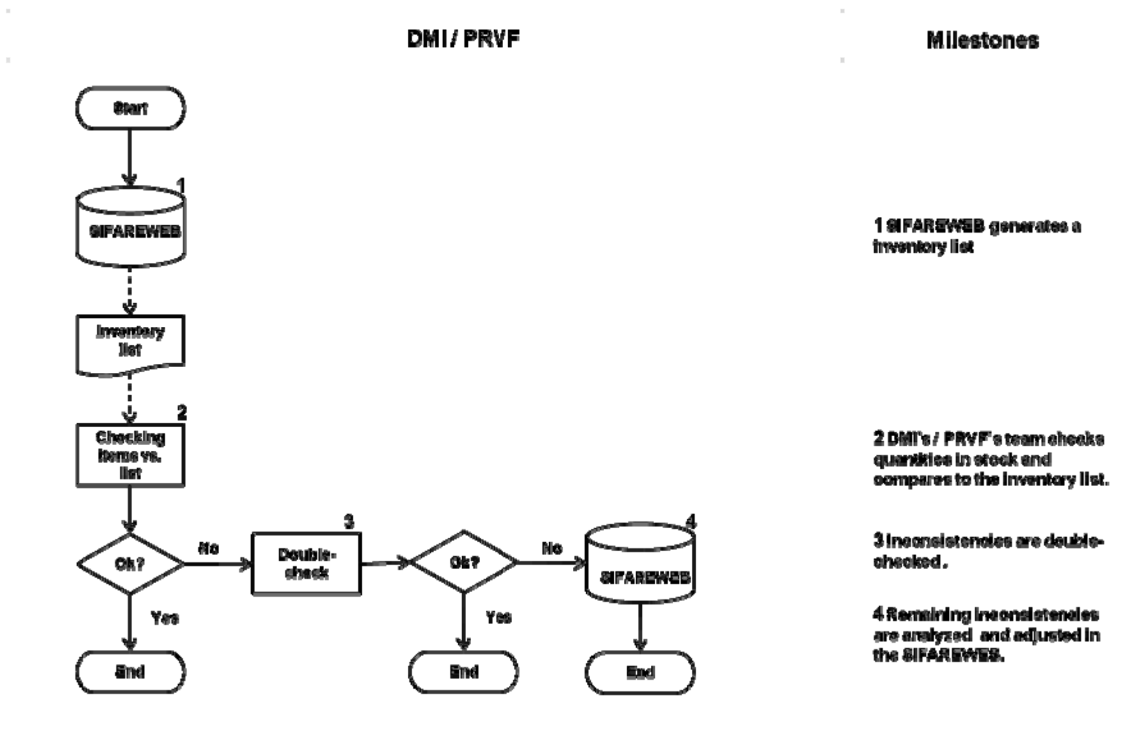

Figure 7. DMI and PRVF inventory flow chart

1. SDAB's Center Warehouse

The average annual number of items stored in the DMI is about 390,000 and the average annual value of stock is US$ 2,242,994. The DMI verifies the inventory manually once a year. The checking is based on a list the SIFAREWEB generates, which contains the existing items and the corresponding location within the warehouse. The inventory conducted in 2010 found 350,000 items. Six people (i.e., one lieutenant, two sergeants, and three soldiers) worked 210 hours to locate and count the items, equating to 1,667 items checked per hour. The inconsistencies between the amounts recorded in the SIFAREWEB and physically checked, as well as the errors of location or storage bin are set in the system. The average time to process the adjustments was 70 hours of one sergeant, in 2010, and involved 44,300 items (i.e., 12.66% of inventory), 27,940 items in excess and 16,394 items missing, accounting for US$ 159,498 and US$ 113,878, respectively.

2. Regional Uniform Sales Offices

The inventory in each PRVF follows virtually the same routine as the DMI. The SIFAREWEB generates an inventory list with which two people usually check the stock at each PRVF. According to information obtained from two PRVFs, the average time spent to perform an inventory is one hour for 207 items checked. Considering the sum of monthly averages of the 28 PRVF inventories was 148,963 items in 2010, and the fact that the inventory is verified at least twice a year, the total time spent auditing the inventory is estimated at 1,440 hours.

D. SALES

The 28 PRVFs sell military uniforms by cash, check or payroll deduction. According to the SDAB's instructions, the PRVF should work not only during working hours, but also on alternative schedules to better meet the military needs. The average time to register a five-item sale is 1 minute. Considering that in 2010 the total items sold were about 200,000 items, the time spent on processing the sales was 667 hours (25 hours per PRVF, on average). When customers cannot find uniform items they need in the PRVF, the salesperson records the fact in the SIFAREWEB as backorders. AB3 uses sales and backorders for uniform distribution and acquisition planning. In 2010, the SIFAREWEB had 2,500 backorders, which represents 1.25% of total sales in that year.

E. ANALYSIS

Based on the above descriptions of the USS routines and data, Table 2 was developed to highlight the relevant processes, summarize the problems and gaps in each sub-process, and concisely present the 2010 quantitative data gathered from SDAB. An additional assessment was made for each relevant sub-process pertaining to whether or not it could benefit from the introduction of RFID technology, and the results of this assessment are included in the last two columns of the table.

The data presented in Table 2 lead to the conclusion that RFID technology could improve the efficiency of several activities performed by the Uniform Sales System (USS), due to the reduction of manual contact with the products and accurate control over the uniform items provided by that technology. In addition to the handling of inventory being time consuming, the situation is aggravated by human errors. Human errors result in more time being required to both verify work performed by humans, and solve problems arising from these errors. In 2010, the time spent on material handling phases of receiving, inventories, and distribution to PRVF was 11,107 hours. Although productivity may be considered satisfactory within the reality of USS operations, it is clear from the RFID assessment shown in Table 2 that the presence of RFID technology in a new scenario can improve those processes.

Table 2. USS processes' gaps and problems, quantitative data, and potential applications of RFID technology

Process 1: Acquisitions for the SDAB's Central Warehouse				
Sub-processes	**Gap / Problem**	**Quantitative data (2010)**	**RFID benefit**	
			Yes	**No**
Acquisition procedures	Lengthy procurement	7 months		✓
Receiving of materials from suppliers	Manual, time-consuming initial receiving (Receiving 1)	29 hours (200 boxes/h)	✓	
	Long wait for the laboratory's report (laboratory is a bottleneck)	25 days		✓
	Manual, time-consuming final receiving (Receiving 2)	150 hours (2,000 items/h)	✓	
	Manual, time-consuming storage	750 hours (400 items/h)		✓
	Manual data record in the SIFAREWEB; subject to human errors	70 hours	✓	
Process 2: Distribution to the Uniform Sales Regional Office				
Sub-processes	**Gap / Problem**	**Quantitative data (2010)**	**RFID benefit**	
			Yes	**No**
SDAB's distribution routine	GRM's items collected manually; time consuming and subject to human errors	1,724 hours (129 items/h)	✓	
	Manual, time-consuming double-check	403.2 hours (552 items/h)	✓	
	Manual, time-consuming packing	44.8 hour (5,000 items/h)		✓
Receiving of material in the PRVFs (28)	Manual, time-consuming checking, and discrepancies (quantities vs. GRMs) - error rate: 3.17%	6,300 hours (35 items/h)	✓	
Process 3: Inventory				
Sub-processes	**Gap / Problem**	**Quantitative data (2010)**	**RFID benefit**	
			Yes	**No**
SDAB's Center Warehouse	Check inventory; manual and time–consuming	210 hours (1,667 items/h)	✓	
	Inventory inconsistencies: inaccuracy (12.66%) and time-consuming adjustments	70 hours	✓	
PRVF (28)	Manual, time-consuming inventory checking	1440 hours (207 items/h)	✓	
Process 4: Sales				
Sub-process	**Gap / Problem**	**Quantitative data (2010)**	**RFID benefit**	
			Yes	**No**
Checkout	None	667 hours	✓	

THIS PAGE INTENTIONALLY LEFT BLANK

V. USS PROCESS UNDER RFID TECHNOLOGY (“TO-BE” PROCESS)

Based on the USS process flows and potential applications of RFID technology in the USS, as presented in Table 2, the processes were reorganized to reflect the potential situation after an RFID implementation. This chapter presents these reorganized USS processes with clear comparisons to the existing processes. Sarac et al. (2010) advocate that companies may gain more effectiveness in their overall supply chains by integrating RFID technology through new business architectures (i.e., reengineering models). The author acknowledges the relevance of reengineering models, but recognizes that those models may also involve other investments, an aspect that goes beyond the scope of this project. Therefore, this report minimizes the changes to the SDAB’s business processes, and only makes changes required to fit the RFID features and capture data about time spent and human resources deployed in the operations focusing on improvements in the current USS system.

This section presents the new USS routines considering the integration of RFID, and includes the estimated time and personnel that would be involved in the activities according to the data gathered from the SDAB. The operations performed in 2010 are used as the baseline to introduce the new scenario (“to-be”).

A. ACQUISITIONS FOR THE SDAB’S CENTRAL WAREHOUSE

In this process, the RFID technology impact point is in the “receiving of materials from suppliers” sub-process (Table 2). In the new scenario, the suppliers ship uniforms to SDAB with the RFID tags in each standardized cardboard box and in each item inside the boxes. After the carriers deliver the cardboard boxes at the DMI, the DMI’s team places the boxes on pallets and passes them through a fixed gate reader. The reader reads the tags, and the SIFAREWEB automatically records the data. The SDAB estimates the DMI would spend 2 minutes to place the boxes on the pallets and setup the reader, and 10 seconds to read (and re-read, if necessary) the tags, per delivery. Considering that in 2010, the DMI received 5,800 items (boxes) in 171 deliveries, the total time devoted to receiving products from suppliers would be 6.1 hours. The new process may eliminate the “Receiving 2” task (see Figure 5) because “Receiving 1” task provides full counting in the moment the DMI receives the uniforms from suppliers.

Before sending the uniform samples to the laboratory, the DMI’s team reads the tags of selected items by using a handheld reader. With the sample in hand, the laboratory analyzes it, and indicates the approval or disapproval by scanning the samples tags with a handheld reader. Immediately, the SIFAREWEB updates the information about the related lot, and the DMI can store the boxes, or coordinate with the AB3 the return of the products to the supplier. The information from SIFAREWEB does not substitute for the formal report, but it enables the DMI to put the uniforms on the shelves right after the laboratory updates the system. The estimated time to record in the SIFAREWEB the output of a sample to the laboratory and its return to the DMI is 1 minute per type of item, which means 6.75 hours for the 405 items analyzed in 2010.

Figure 8 presents the new process with RFID technology, which includes additional steps that would provide better control and speed.

The SDAB plans to start receiving the uniforms from suppliers at the beginning of 2013 when the current contracts with the suppliers expire and new ones will include the clause that request the suppliers to sell the items with the tags embedded in them. Until then, the DMI’s team will be in charge of putting tags in the uniforms in stock and in those received from suppliers. The SDAB estimates to spend 308 working hours of three people to place tags in the current inventory, 105 hours in the next 42 lots received until the end of 2011, and 204 hours in 2012.

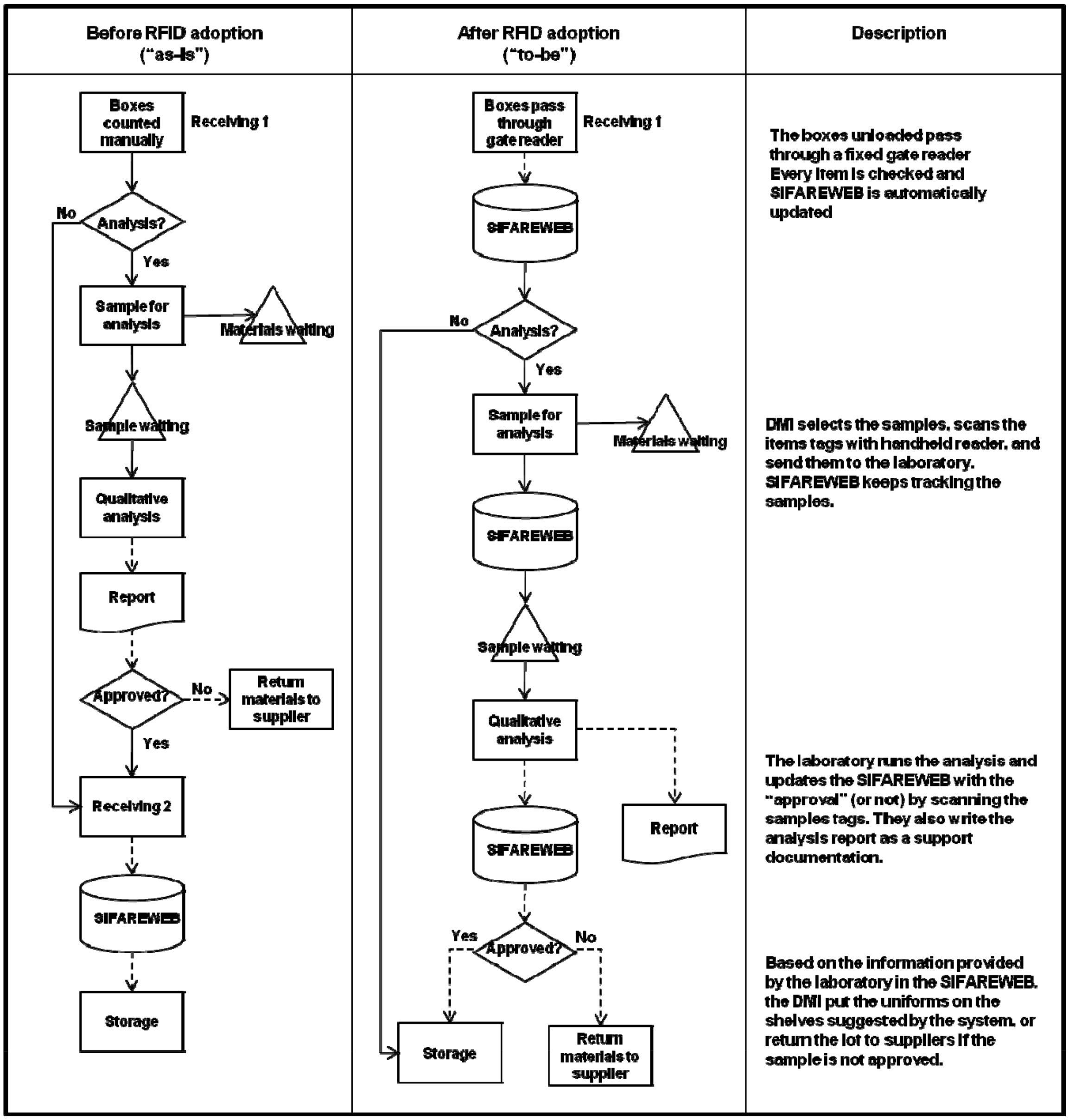

Figure 8. Work flows of the receiving routines in the SDAB

B. DISTRIBUTION TO THE REGIONAL UNIFORM SALES OFFICES

As mentioned in Chapter IV, this process is a big SDAB concern due to the current distribution capacity. The time spent to perform tasks such as pick the uniforms from the shelves and verify the quantities with the GRM is becoming a significant constraint in the current scenario of continued sales growth (uniform sales grew about 25% per year since 2008). The SDAB predicts that without process changes, the PRVFs will incur stock-outs more often. RFID technology can help to minimize current problems even if the task remains the same. The purpose of using the technology is to speed the distribution process and at the same time to provide more control over the assets within the DMI. Figure 9 shows the steps of the distribution to the PRVF process with the integrated RFID technology.

1. SDAB's Distribution Routine

In this sub-process, the DMI still picks the uniforms based on the GRM approved by the AB3, and the labor force employed remains the same. However, the SDAB estimates the time spent to pick the items listed in the GRM will be lower because the DMI team can use a handheld reader to help localize items stored in shelves that do not match with the SIFAREWEB records when they perform that task. In other words, RFID minimizes the impact of the recurrent problem of spending time looking for boxes placed in inappropriate shelves within the storage area. Based on 2010 numbers, the SDAB estimates to reduce by 15% the total hours devoted to pick up the uniforms because of the use of RFID technology.

After accommodating the material for distribution in boxes for delivery, the DMI team records in the SIFAREWEB the number of boxes used. They print RFID labels and stick them on the boxes. The boxes pass through the fixed gate reader to verify the quantities, to associate the items with the corresponding box, and to generate the list of contents for each box. Then, the DMI team places the boxes on pallets in the shipping area where they wait for transportation. Before loading, the boxes pass again through the gate reader so that the person or company in charge of the delivery can check what exactly they are receiving.

The time spent to print RFID labels and stick them on the boxes delivered to the PRVFs annually would be 1.4 hour of one soldier. The packing time would remain the same, but the SDAB estimates that the time to read the uniform tags through the fixed gate for the same number of items and GRMs processed in

2010 (222,600 items under 420 GRM) would be 14 working hours of one soldier, including the reader setup times. Figure 9 shows the procedures added to the distribution process.

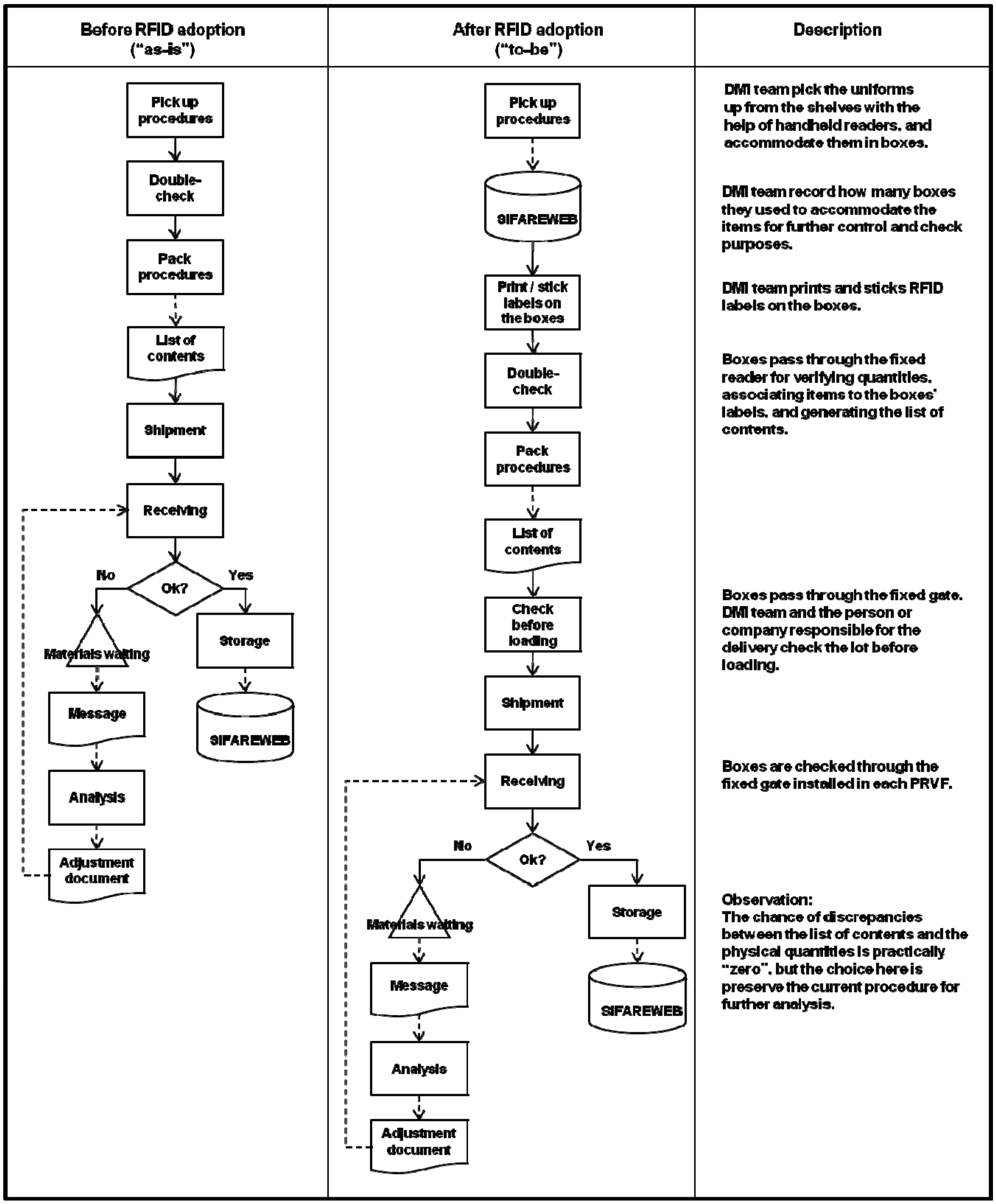

Figure 9. Work flows of the distribution to the PRVFs

2. Receiving of Material in the PRVF

Each PRVF will have a small fixed gate reader to count the items received from SDAB, which replaces the manual counting. Since the boxes and items inside them are labeled with RFID tags, as they pass through the gate reader the uniforms will be checked individually against the list of contents. Based on the number of items shipped to the PRVFs in 2010, the total time spent to set up the readers and check the quantities would be about 14 hours, and one person could perform the task. The SDAB also expects to reduce the discrepancies between the GRM and physical quantities to practically zero.

C. INVENTORY

Inventories performed with the RFID technology will reduce drastically the time spent to perform the item counting. Considering the average stock of 390,000 items, the SDAB expects that three people of the DMI's team will be able to check the items on the shelves in 1 hour. This reduction in time easily enables the DMI to run two inventories per year as recommended by the FAB's internal control. In turn, the inventory in each PRVF may take about 10 minutes, considering one person performing the task. This means approximately 10 working hours per year to run two inventories in all 28 PRVFs. In addition, the SDAB predicts that the use of RFID technology will reduce the discrepancies between physical quantities and the SIFAREWEB records from current 12.66% (see Table 2) to a much smaller percentage of the total inventory, and the human resources involved in the current adjustments will become negligible. Figure 10 shows the inventories workflows. As seen here, the only change in the process is the automation.

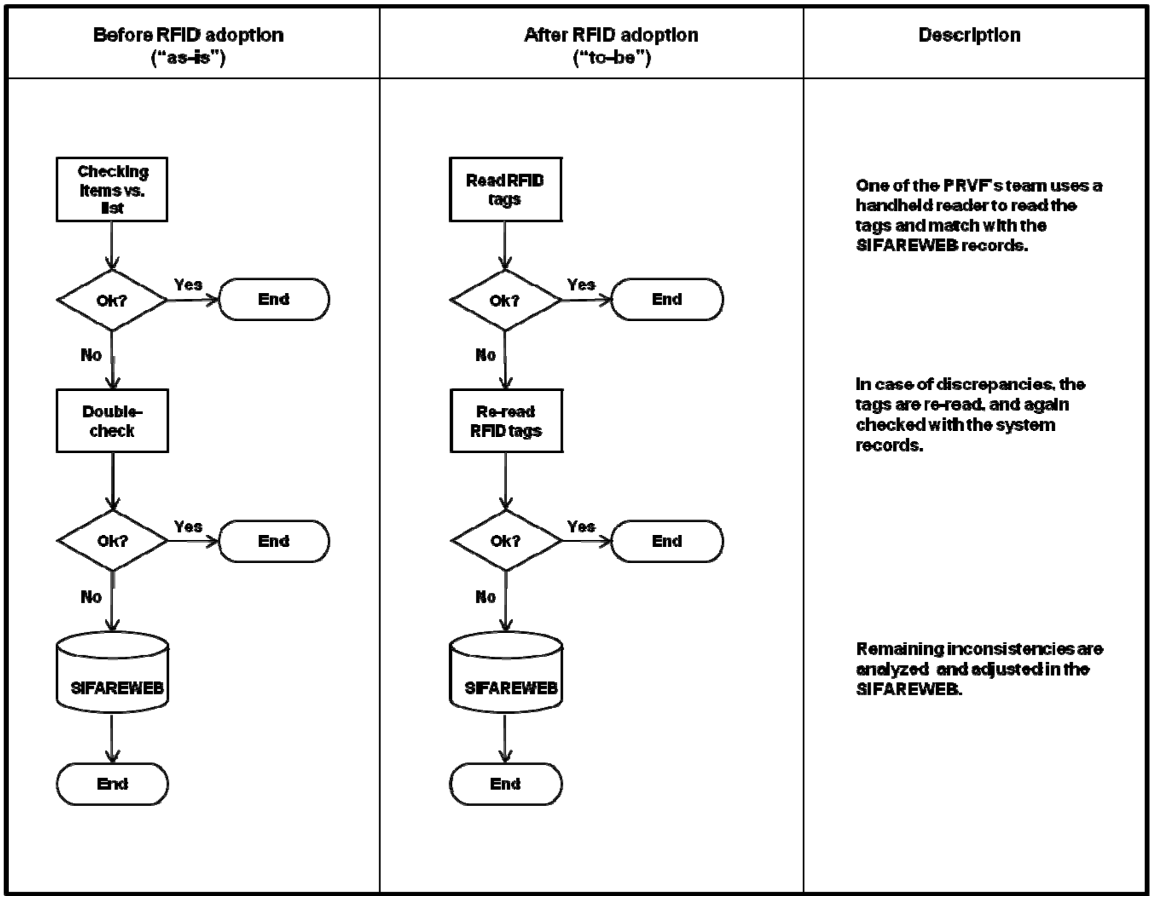

Figure 10. Work flows of inventories at the DMI and PRVFs

D. SALES

Currently, an experienced seller registers a sale of five items in about 1 minute. The reader installed in each PRVF will enable the seller to do his job in half of time for the same number of items or more. The seller passes the items through the reader, gets the identification number from the customer, and closes the sale. The estimated time to process the same quantities sold in 2010 (200,000 items) is 333 hours.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. COST-BENEFIT ANALYSIS

This chapter provides the cost-benefit analysis (CBA) of adopting RFID technology in the USS. The costs presented here were gathered from the SDAB team, which researched the prices of each item necessary to implement RFID in the USS based on the technical specifications they have at hand. Seeking data consistency about the items included in the SDAB's proposed investment, the author used the RFID literature provided by Lahiri (2005), Jones and Chung (2007), and Brown (2007), which describes the components commonly used in RFID adoption.

The benefits come from the author's analysis of the redesigned USS processes considering the use of RFID. Regarding the benefits assessment, this project considers the SDAB's objective of improving efficiency considering exclusively RFID technology integration to the current USS processes, and does not suggest drastic changes that may (or may not) provide other benefits from the management standpoint.

In order to perform the CBA, the author sets out some assumptions, described in Section C, whose objective is to clarify under what conditions the quantitative results presented here are valid.

A. COSTS OF ADOPTING RFID TECHNOLOGY

The technical project that the SDAB team developed includes all direct costs required to implement RFID in the entire USS. The costs include hardware, software, services, and maintenance. Each expense is explained below.

1. Tags

The SDAB will require that suppliers manufacture and sell uniforms to the AF with the tags embedded in each item as of 2013. The suppliers will also have to follow the EPCglobal11 specification. The SDAB expects a 6% increase in the selling prices charged by suppliers due to the investments they will need to make to meet the new contract requirements. Based on the total acquisition costs in 2010, the annual increase would be US$138,700 as of 2013.

Regarding the current stock, the DMI team will put tags in each item within the first year of new operations where RFID is present. They need approximately 335,000 passive tags, which cost between US$0.15 and US$0.20 (average US$0.18). Besides, the SDAB should purchase tags to affix in the items to be received in 2011 and 2012. The additional number of tags needed is 73,600 (42 deliveries of 1,700 items on average) plus 222,600, the number of items that the SDAB estimates they will receive in 2012. The SDAB intends to buy all tags in 2011, and there is no recovery cost because the SDAB does not intend to re-use them. The total tag cost is US$113,616.

In addition to the tags for the uniform items, the SDAB will print and stick labels in cardboard boxes used for distribution of products to the PRVFs. The estimated cost of the labels is US$1,134 per year.

2. Labor Force

In 2011 and 2012, the SDAB will use extra resources to put the RFID system into practice. The activity of labeling the uniforms in stock (in 2011) and the items received from suppliers (until 2012) is estimated to take 617 working hours of one sergeant and two soldiers, which will cost US$17,913. Table 3 includes the labor costs added to the SDAB's project due to the labeling activity distributed accordingly in 2011 and 2012.

---

[11] EPCglobal is leading the development of industry-driven standards for the Electronic Product Code™ (EPC) to support the use of Radio Frequency Identification (RFID) in today's fast-moving, information rich, trading networks. Retrieved from http://www.gs1.org/epcglobal (accessed 11 Mar 2011).

3. Hardware

The SDAB plans to buy handheld and stationary readers (mounted on portals and peripherals linked to computers), and label printers. The hardware will be applied as follows:

- DMI – handheld and stationary readers (portals and computer peripherals), and printers for labeling the boxes for transportation
- PRVF – handheld and stationary readers (portals and computer peripherals)
- Laboratory – stationary reader (computer peripherals)

The stationary readers to be mounted on portal the SDAB will purchase for the DMI and for each PRVF cost US$1,992 and US$1,522, respectively. These prices include all accessories needed for installation. The reader to be linked to a computer (computer peripheral) costs US$400 each. Handheld readers cost US$3,436, and printers, US$4,083 each.

4. Software

The SIFAREWEB update will need 320 function points[12] at a total cost of US$138,500. The estimated cost of the middleware is US$65,900.

5. Other Costs

In addition to the basic costs mentioned before, there are other costs necessary to implement or maintain the RFID system. They are as follows:

- Installation and configuration services - the estimated cost of the installation and configuration services is US$ $18,000
- Testing - the SDAB plans to run RFID tests, which will cost US$12,000

[12] A function point is a unit of measurement to express the amount of business functionality an information system provides to a user. Retrieved from http://en.wikipedia.org/wiki/Function_point (accessed 28 Mar 2011).

- Training - the total cost is estimated to be US$6,000
- Maintenance - the annual cost of the system maintenance is US$12,000
- Infrastructural services - the DMI requires an investment of US$24,000 for infrastructural services. In five of the PRVFs, the SDAB estimates to spend US$3,000 to upgrade their internal network infrastructure. The other 23 PRVFs require small changes in cables, whose related costs are negligible.

Table 3 summarizes the costs SDAB will incur to implement RFID technology in the USS. All necessary investments are included in the table.

Table 3. Costs of adopting RFID by the Uniform Sales System (USS)

COSTS				
Item		**Quantity**	**Unit price (US$)**	**Total (US$)**
Acquisition cost (annual increase as of 2013)		1	138,700.00	138,700.00
Tag (for each item) - 2011 and 2012		631,200	0.18	113,616.00
Label (for boxes) - annual		6,300	0.18	1,134.00
Labor force - in hours (only in 2011 and 2012)	1 sgt	617	17.30	10,674.85
	2 sd	617	5.87	7,237.81
Hardware	portal reader (DMI)	1	1,992.00	1,992.00
	portal reader (PRVF)	28	1,522.00	42,616.00
	reader linked to computer	31	400.00	12,400.00
	label printer	2	4,083.00	8,166.00
	handheld reader	31	3,436.00	106,516.00
Software	SIFAREWEB updating	1	138,500.00	138,500.00
	Middleware	1	65,900.00	65,900.00
Installation and configuration services		1	18,000.00	18,000.00
Testing		1	12,000.00	12,000.00
Training		1	6,000.00	6,000.00
Maintenance (annual)		1	12,000.00	12,000.00
Infrastructural services	DMI	1	24,000.00	24,000.00
	5 PRVF	1	3,000.00	3,000.00

B. BENEFITS OF ADOPTING RFID TECHNOLOGY

The integration of RFID into USS seems like it will provide the benefits intended by SDAB. The RFID technology speeds current USS tasks, enables better control over the assets, and ensures inventory accuracy. The replacement of manual steps by RFID technology clearly saves time spent with the USS operations and, in some cases, reduces the number of operators required to perform certain activities. Table 4 shows the comparison between the “as-is” and “to-be” processes in terms of annual time and number of operators required to perform each USS task.

1. Process Improvement

The USS process improvement not only refers to the total time and operators saved, but also to some tasks eliminated or added under the RFID system. Table 4 presents all tasks where RFID technology affects the performance and the quantitative outcomes resulting from the automation. According to Brown (2007), the adoption of RFID may reduce time of current operations, remove tasks, and add new steps to the business process; this is exactly what happens in the USS. The time spent counting in activities such as "receiving material from carriers" and "inventories in the DMI" decreases drastically due to automation. At the same time, the automation provides accurate results by eliminating the need to verify physically the products against invoices and inventory lists, respectively. On the other hand, to fully achieve the potential of the RFID tool naturally requires adding new procedures to the USS. As seen in Chapter V ("to-be" process), uniform sample movements between the DMI and the laboratory are now tracked under RFID; boxes for transportation receive labels that enable better control over the products; but, new steps are also required, as well as new resources, to put the routines into practice.

The automation also allows the SDAB to eliminate adjustment routines currently performed due to human errors during manual tasks such as counting items and recording invoice data in the SIFAREWEB. Under the RFID system, those discrepancies should be zero since there is no manual verification or manual data input in the SIFAREWEB.

Using data presented in Chapters IV and V, Table 4 summarizes the time saved (or added), the number of operators and labor-hours required to perform each USS task per year by adopting the RFID technology. More specifically, Column 1 specifies the tasks that would be impacted by RFID; Columns 2-4 show the current number of workers need per task, the number of labor hours per person per year, and the resulting total labor hours per year for each task. Columns 5-7 show the same worker/labor information for the scenario where RFID is in use. Column 8 shows the per person per year labor hours saved by using RFID for each task (Column 3 minus Column 6) whereas Column 9 shows the total labor hours saved per year for each task (Column 4 minus Column 7), with the percent savings for total labor hours is given in Column 10. Despite the existence of new steps, the new scenario would be more efficient, not only in terms of the speed with which the USS parties perform their activities, but also because of better control over assets.

Table 4. Operators, time, and labor-hours allocated to "as-is" and "to-be" USS processes

OPERATORS, TIME, AND LABOR-HOURS BEFORE AND AFTER RFID ADOPTION									
Process 1: Acquisition for the SDAB's Central Warehouse									
Sub-process: Receiving of materials from suppliers									
	As-is			**To-be**			**Result after adoption of RFID**		
Tasks	**# of operators**	**Time per task per year per person**	**Total labor-hours per year**	**# of operators**	**Time per task per year per person**	**Total labor-hours per year**	**Time saved/added per task (hrs)**	**Labor-hours saved per year**	**Labor-hours reduction (%)**
Initial receiving (or Receiving 1)	4	29	116	4	6.1	24.4	22.9	91.6	79.0%
Final receiving (or Receiving 2)	3	150	450				150	450	100.0%
Storage	5	750	3750	5	750	3750	0	0	0.0%
Data record in the SIFAREWEB	2	70	140				70	140	100.0%
Tracking uniform samples (DMI / Lab)				1	6.8	6.8	-6.8	-6.8	-
Process 2: Distribution to the Regional Uniforms Sale Offices									
Sub-process: SDAB's distribution routine									
Pick up procedures	4	1724	6896	4	1465.4	5861.6	258.6	1034.4	15.0%
Verification	2	403.2	806.4	2	14	28	389.2	778.4	96.5%
Packing procedures	4	44.8	179.2	4	44.8	179.2	0	0	0.0%
Labeling boxes for transportation				1	1.4	1.4	-1.4	-1.4	-
Check before loading	2	14	28	1	14	14	0	14	50.0%
Sub-process: Receiving at PRVF's									
Receiving (per PRVF)	2	225	450	1	0.5	0.5	224.5	449.5	99.9%
Process 3: Inventory									
Sub-process: DMI inventory									
Inventory	6	210	1260	6	2	12	208	1248	99.0%
Adjustments	1	70	70				70	70	100.0%
Sub-process: PRVF inventory									
Inventory (per PRVF)	2	51.4	102.8	1	0.4	0.4	51.0	102.4	99.6%
Process 4: Sales									
Sub-process: PRVFs sales									
Checkout (per PRVF)	1	23.8	23.8	1	11.9	11.9	11.9	11.9	50.0%

2. Cost Savings

The benefits of adopting RFID are seen in the reduction of resources necessary to perform the USS activities. The immediate consequence of the use of that technology is the reduction of labor and the number of operators needed to perform certain tasks. This reduction should be represented in monetary value for comparison with the costs required to provide the expected benefits.

Table 5 shows the annual cost savings of the USS under RFID technology. The table presents the operators, time saved per task per person (from Column 8, Table 4) and the corresponding dollar amount saved per task per year. The operators' costs per hour are drawn from Table 6.

In the AF, the fact that a task requires less time of an airman or fewer airmen to accomplish does not mean that there is a real reduction of wages, since the military will continue to receive the same payment by performing other activities. However, from the management standpoint, labor saved in a process may represent more efficiency, if benefits outweigh the cost of a process change.

The idle capacity resulting from process improvements such as those present in the USS, under RFID technology, represents resources available, which managers may employ in other processes. The existing jobs represent costs of projects or process in the SDAB, and depending on what and how those resources are used, the results could be more or less valuable, more or less efficient.

Table 5. Cost savings under RFID technology

COST SAVINGS				
Process 1: Acquisition for the SDAB's Central Warehouse				
Sub-process: Receiving of materials from suppliers				
Tasks ("as-is" and / or "to-be")	**Operators**	**Time saved (hours)**	**Cost per hour**	**Annual cost savings**
Initial receiving (or Receiving 1)	1 sgt	22.9	$17.30	$396.20
	3 sd		$5.87	$402.95
Final receiving (or Receiving 2)	1 maj	150	$45.75	$6,862.80
	2 sgt		$17.30	$5,190.36
Data record in the SIFAREWEB	1 sgt	70	$17.30	$1,211.08
	1 sd		$5.87	$410.57
Tracking uniform samples (DMI / Lab)	1 sd	-6.8	$5.87	($39.59)
			subtotal 1	**$14,434.37**
Process 2: Distribution to the Regional Uniform Sales Offices				
Sub-process: SDAB's distribution routine				
Pick up procedures	1 sgt		$17.30	$4,474.09
	3 sd	258.6	$5.87	$4,550.32
Double-check	1 sgt		$17.30	$6,733.63
	1 sd	389.2	$5.87	$2,282.78
Labeling boxes for transportation	1 sd	-1.4	$5.87	($8.21)
Check before loading	1 sgt	14	$17.30	$242.22
			subtotal 2	**$18,274.83**
Sub-process: Receiving at PRVF				
Receiving (28 PRVFs)	28 sgt	225	$17.30	$108,997.61
	28 sd	224.5	$5.87	$36,869.42
			subtotal 3	**$145,867.03**
Process 3: Inventory				
Sub-process: DMI inventory				
Inventory	1 ten	208	$30.85	$6,417.76
	2 sgt		$17.30	$3,598.65
	3 sd		$5.87	$1,219.99
Adjustments	1 sgt	70	$17.30	$1,211.08
			subtotal 4	**$12,447.48**
Sub-process: PRVF inventory				
Inventory (28 PRVFs)	28 sgt	51.4	$17.30	$24,899.90
	28 sd	51	$5.87	$8,382.25
			subtotal 5	**$33,282.15**
Process 4: Sales				
Sub-process: PRVFs' sales				
Checkout	28 sd	11.9	$5.87	$1,954.33
			subtotal 6	**$1,954.33**
			Total cost savings	**$226,260.19**

Table 6. Average wage per hour[13]

Rank	Average wage per hour
Major (maj)	$45.75
First Lieutenant (ten)	$30.85
2º Sergeant (sgt)	$17.30
Soldier 2º class (sd)	$5.87

C. ASSUMPTIONS

Although the data collection for the CBA proposed for this project intends to be exhaustive, the author makes the following assumptions to perform the analysis and provide a better understanding of how he obtains the results:

- Period analyzed – the analysis covers a five-year period (from 2011 to 2015). The SDAB does not foresee new investments in the RFID system in the next five or seven years.
- RFID tags – the author increases by 1% the total quantity of tags needed to identify the items in the DMI's stock and those the DMI will receive until 2012 to replace tags damaged or lost
- Acquisition cost – the SDAB's total acquisition cost in 2010 is the basis to calculate the increase of 6% in the acquisition cost from 2013 to the last year considered in the analysis
- Labor cost – the distribution of labor and its costs required to label the uniforms received from suppliers in 2011 and 2012 is 1/3 and 2/3, respectively
- Transportation –the analysis does not consider changes in transportation operations since they are not affected "directly" by the adoption of RFID technology

[13] The average wages per hour consider 7 hours per day, 22 days per month, and the average payment per rank in 2010. The data were gathered from the Subdirectorate of Payment (SDPP).

D. RESULTS OF THE ANALYSIS

After the description of the costs directly related to the adoption of RFID by SDAB, and the estimated benefits provided by the technology, Table 7 presents the results of the analysis considering a period of 5 years, the minimum period during which the SDAB predicts they will not need to make any new investment in the RFID system.

Seeking to demonstrate quantitatively whether the SDAB's project of adopting RFID is worthwhile, the author uses the net present value (NPV) as a tool to calculate the difference between future cash flows and expected benefits within the 5-year period. The NPV enables one to make systematic comparisons between costs and benefits incurred and realized at different stages in time (Stokey and Zeckhauser, 1978).

Under NPV, the costs and benefits are discounted to a certain year and arithmetically added to provide a result used to state whether the benefits justify the costs. The author applies a 6%-discount rate to calculate the NPV of the costs and benefits presented in 2011 constant dollars for the 5-year period considered in this project. The discount rate chosen approximates the Brazilian inflation index for 2010 (i.e., 5.91%) published by the Brazilian Institute of Geography and Statistics (IBGE)[14], and the base year is 2011.

[14] IBGE, Retrieved from http://www.ibge.gov.br.

Table 7. Results of the cost and benefits of adopting RFID

COSTS (US$)					
Item	2011	2012	2013	2014	2015
Tag	113,616				
Acquisition			138,700	138,700	138,700
Label	1,134	1,134	1,134	1,134	1,134
Labor force	11,990	5,922			
Hardware	171,690				
Software	204,400				
Installation and configuration	18,000				
Testing	12,000				
Training	6,000				
Maintenance	12,000	12,000	12,000	12,000	12,000
Infrastructure	27,000				
Total cost	577,830	19,056	151,834	151,834	151,834
BENEFITS (US$)					
Cost savings = Total benefits	226,260	226,260	226,260	226,260	226,260
Net	-351,570	207,204	74,426	74,426	74,426
Discount factor	1.00	0.94	0.89	0.84	0.79
Present value	-351,570	195,475	66,239	62,490	58,953
Total NPV @ 6%	**31,586**				

As seen in Table 7, the positive NPV indicates that the adoption of RFID by the SDAB is a project sufficiently valuable to justify the investments. Based on the costs and benefits gathered in this project, the positive NPV represents the difference between the “as-is” (in this case, “do-nothing”) scenario and the scenario in which RFID is present. The table also shows that the SDAB may recoup the investment in less than three years.

Considering that the massive investment is concentrated in the first year of the period and the fact that the 5-year period is a conservative estimate (SDAB predicts it will not make any new investment before five years at a minimum) and the behavior of costs and benefits from 2013, it is possible to see net benefits as time progresses.

VII. CONCLUSION, LIMITATIONS, RECOMMENDATIONS, AND FURTHER RESEARCH

A. CONCLUSION

This project sought to provide a cost-benefit analysis (CBA) of adopting RFID in the Brazilian Air Force (FAB) Uniform Sales System (USS). The current USS processes were redesigned considering the integration with RFID technology, enabling the comparison between the two operational scenarios (“as-is” and “to-be”) and the analysis of the costs and benefits present in the proposed process change.

The CBA resulted in a number that indicates the SDAB’s intent of implementing RFID is worthwhile. The positive net present value (NPV) calculated shows that the benefits outweigh the costs in the 5-year period considered. The initial investment will improve the USS efficiency by reducing labor time of handling the stock and at the same time providing better control over the uniform items in the supply chain.

Following the framework for RFID system implementation proposed by Ngai et al. (2010), the author and the SDAB had the opportunity to revisit the current USS business processes to assess their suitability and, more importantly, generate information about resources and time involved, which were crucial to monetize the direct benefits resulting from RFID adoption and contrast them with the costs. Time and work force utilized in 2010 USS operations were investigated and formally described, allowing for a consistent analysis of the impact of RFID technology in the USS and the outcomes of the process change.

As mentioned in Chapter VI, the labor saved does not represent money saved because the Air Force payroll will not change due to the RFID adoption. However, the work force effort constitutes costs that can (and should) be avoided when RFID is in place. Those costs or resources will be available to benefit other projects or processes elsewhere at the SDAB. In this sense, the CBA also estimates what and how much effort can be redirected to other activities.

Making an analogy with what Lee (2000) says in *Creating Jobs vs. Creating Wealth*, the labor saved in the USS after RFID may provide more efficiency if it is employed accordingly elsewhere within the SDAB.

> The relevant question is not whether a government project creates jobs, but whether the workers in those jobs will create more wealth than they would in other jobs. (Lee 2000, p. 43)

Regarding the RFID system, Lahiri (2005) says that it is a data-collection technology. "Business process change will offer the ultimate benefit in using RFID technology" (Lahiri, 2005, p. 144). Although RFID is the right choice in terms of technology, and the CBA indicates it is worthwhile, the SDAB must address the fundamental question of how to use the data, and extract maximum advantage from the data to improve continuously its processes.

B. LIMITATIONS

Regarding to the limitations of this study, the integration of RFID with the USS does not consider drastic changes in the current system architecture. The SDAB might gain more effectiveness in its supply chain by integrating RFID technology through a new architecture (Sarac et al., 2010). Although this approach may require other investments, and transform the environment in which RFID would be integrated, the cost and benefit analysis result certainly would differ from the one provided by this project.

Another aspect is the risk inherent to any real-world project. Lahiri (2005) and Brown (2007) suggest assigning risk factors when performing a technology project justification like the RFID adoption intended by SDAB. They use a rank scale (e.g., low to high, 1 to 5) and assign factors (or weight) to each risk according to its degree. A multidisciplinary team of practitioners (SDAB members), RFID experts, suppliers, and vendors should support the task of coming up with a good risk pool, monetize it and include in a CBA or at least document the information for the decision-making process. The author acknowledges the relevance of the issue, but chooses not to try to quantify and monetize the risk. However, this project seeks to provide a conservative cost and benefit analysis by using the shortest plan cycle (five years instead of seven) estimated by SDAB. In addition, it recommends some actions to the SDAB's members, which address potential risks they may face and should manage.

The result presented in this project is highly data dependent. Despite the SDAB representatives' expertise of estimating time and personnel data incorporated in the USS current processes and in the potential new scenario presented by the author, the net benefit associated with the integration of RFID may be more or less realistic depending on the data accuracy.

Concerning the labor-hours that the SDAB may save, it is important to mention that some actions should be taken to relocate or redirect those resources that would be available after RFID in order to ensure the use of the technology would provide the net benefit presented in this project. Otherwise, the SDAB will have idle capacity instead of the pursued efficiency.

C. RECOMMENDATIONS

The study conducted about the Uniform Sales System (USS) revealed some issues that, in the author's view, may be addressed by the SDAB to ensure the consistence of the RFID project and that the opportunities to improve the USS after RFID are completely explored.

1. Small-Scale Proof-of-Concept Testing

As Ngai et al. (2010) emphasizes, a small-scale proof-of-concept should be conducted to guarantee that the RFID solution is ready for utilization considering the redesigned process where the technology is present. The testing should preferably be performed in the real operational environment, and the pilot users should take part in the testing.

This is a great opportunity to verify RFID software and hardware, assess the estimated performance in the new scenario, and eventually make adjustments in the planning routines. The performance parameters set for the USS "to-be" processes and used in the cost-benefit analysis can serve as targets, or a basis for improvements.

2. Change Management

"Resistance to change is inevitable" (Ngai et al., 2010, p. 2596). In spite of speeding tasks and clearly providing more efficiency to the USS, operators and stakeholders (e.g., suppliers, customers) may resist the process change. The SDAB should identify the likely impact of the changes and minimize it by informing all accordingly and determining personnel reassignments or reallocations that will result from RFID system implementation.

3. Quality Analysis Performed by the Laboratory

Although the SDAB is aware of the existing queue before the uniform sample analyses performed by the laboratory, RFID utilization will increase the significance of that bottleneck due to the speed gained in tasks that come before and after the analyses. The high level of the DMI inventory will still disguise the problem, but as the stock level goes down or a particular item, which does not exist on the shelves, is waiting for the laboratory approval to be moved on, the limited capacity of the laboratory will become a more serious concern.

Therefore, the SDAB should consider eliminating the analysis performed in samples of lots delivered by suppliers and reinforce penalties in the contracts when suppliers do not meet uniform specifications determined in the bidding. In case of discrepancies, RFID will ease the identification of the supplier, the item's lot, and other information contained in the tag while embedded in the uniform. At the same time, the SDAB may work with the suppliers to stimulate them to improve their quality control to minimize discrepancies.

4. Continuous Improvement

Once RFID is in place, the SDAB should work to ensure sustained efficiency in its operations under the new system. It has to review the performance measures collected during the RFID implementation to gather the precise information necessary to give feedback on the USS. Operators' and other users' comments on the processes have to be analyzed to identify technical and operational problems or issues that should be addressed to ensure the USS' effectiveness.

D. SUGGESTIONS FOR FURTHER RESEARCH

This study focuses on cost and benefit analysis of integrating RFID technology with the Uniform Sales System. The USS projected scenario where RFID is present suggests interesting opportunities for further research in operations management and process management approaches. In particular, researches may address the following two topics related to the USS, which represent great opportunities for improving efficiency:

- Inventory management at DMI (stock levels, economic order quantity, holding cost)
- Logistic of transportation for uniform distribution to the PRVFs (cost, efficiency, readiness)

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Apte, U. M., Dew, N., and Ferrer, G. (2006, Jan 30). *What is the right RFID for your process?* Retrieved from http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA498250&Location=U2&doc=GetTRDoc.pdf.

Bentkover, J. D., Covello, V. T., and Mumpower, J. (1986). *Benefits assessment: The state of the art*. Dordrecht, Holland; Boston, MA: D. Reidel Publishing Company.

Brazilian National Congress (1993).*Law nr. 8666*. Retrieved from <http://www.planalto.gov.br/ccivil_03/Leis/L8666cons.htm (accessed 25 Jan 2011).

Brent, R. J. (2009). *Handbook of research on cost-benefit analysis*. Cheltenham, UK; Northampton, MA:Edward Elgar Publishing Limited.

Brown, D. E. (2007).*RFID Implementation*. New York, NY: McGraw-Hill.

Comando da Aeronáutica (2008). *Uniform Sales System*. Brasília: COMAER.

Coyle, K. (2005). Management of RFID in libraries. *Journal of Academic Librarianship, 31*(5), 486-489.

Digitivity Electrical and Electronics Industry Marketplace. (2008, Dec 2). *RFID tags: tracking its cost-effectiveness*. Retrieved from http://www.digitivity.com/articles/2008/12/rfid-tags.html.

Fries, J. L., Turri, A. M., Bello, D. C., and Smith, R. J. (2010). Factors that influence the implementation of collaborative RFID programs. *The Journal of Business and Industrial Marketing, 25*(8), 590-595.

Jones, E. C., and Chung, C. A. (2007). *RFID in logistics: a practical introduction*. Boca Raton, FL: Taylor and Francis.

Lahiri, S. (2005).*RFID sourcebook*. Upper Saddle River, NJ: IBM Press.

Lee, D. R. (2000).Creating jobs vs. creating wealth. (2000, Jan). *Freeman*. Retrieved from http://search.proquest.com/docview/196600237?accountid=12702.

Merkhofer, M. W. (1987). *Decision science and social risk management*. Dordrecht, Holland; Boston; Norwell, MA: D. Reidel Publishing Company.

Ngai, E. W. T., Moon, K. K. L., Riggins, F. J., and Yi, C. Y. (2008). RFID research: an academic literature review (1995–2005) and future research directions. *International Journal of Production Economics 112*(2), 510–520.

Ngai, E. W. T., To, C. K. M., Moon, K. K. L., Chan, L. K., Yeung, P. K. W., and Lee, M. C. M. (2010). RFID systems implementation: a comprehensive framework and a case study. *International Journal of Production Research, 48*(9), 2583.

Presidency of the Republic of Brazil.(2005). *Decree nr. 5450*. Retrieved from http://www.planalto.gov.br/ccivil_03/_Ato20042006/2005/Decreto/D5450.htm (accessed 19 Jan 2011).

Prest, A. R. and Turvey, R. (1965). Cost-benefit analysis: A survey. *The Economic Journal, 300*(75), 683-735.

Read, R. W., Grabenstein, M., Snell, P. A., Doyle, S., Byrne, T., and Smith, T. (2004, Feb). *RFID explained - abasic overview*. Robert W. Baird and Co. Incorporated. Retrieved from http://rfidusa.com/superstore/pdf/RFID_Explained_Baird.pdf.

Sarac, A., Absi, N., and Dauzère-Pérès, S. (2010). A literature review on the impact of RFID technologies on supply chain management. *International Journal of Production Economics, 128*(1), 77.

Stokey, E., and Zeckhauser, R. (1978). *A primer for policy analysis*. New York, NY: W.W. Norton and Company, Inc.

Sweeney, Patrick J., II. (2005). *RFID for dummies*. Hoboken, NJ: Wiley Publishing, Inc.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Aeronautics Economy and Finance Secretariat
   Brasília, Distrito Federal

4. Subdirectorate of Supply
   São Paulo, São Paulo